Harvard

VIIA

arvard Engineering Journal

\

~~spended~~ ased publication with vol.13, #1. ~~Evidently~~
merged into "Technology Monthly" and became
"Technology Monthly and Harvard Engineering
Journal"

cf. p. 56-67 of last issue

ote in vol.13, #1 (April 1914).

APRIL, 1913

THE OFFICIAL ORGAN OF THE
ASSOCIATION OF HARVARD ENGINEERS

HARVARD ENGINEERING JOURNAL

A QUARTERLY
DEVOTED TO THE INTERESTS OF
ENGINEERING IN HARVARD UNIVERSITY

VOL. XII. TABLE OF CONTENTS No. 1

Price 35 cents

Apr. 17 1914

HARVARD ENGINEERING JOURNAL

INDEX TO VOLUME XII
1913-1914

PHOTOGRAPH C (*See page 7*) (*An Underground Limestone Quarry*)

HARVARD ENGINEERING JOURNAL

A QUARTERLY

Devoted to the interests of Engineering
in Harvard University

THE OFFICIAL ORGAN OF THE ASSOCIATION
OF HARVARD ENGINEERS

VOL. XII APRIL, 1913 NO. 1

THE COMMERCIAL SIDE OF ENGINEERING AND ITS RELATION TO THE ENGINEER'S SUCCESS

E. L. VERVEER, '98

The engineer upon entering the field of practice is too apt to forget that there is a commercial as well as a technical side to his profession. The cost of any engineering enterprise has an important bearing upon its success. The purchaser is usually more concerned about the cost of a structure than he is about its refined engineering features, while the engineer, in his zealousness to apply his technical knowledge, quite often loses sight of this fact.

Theoretical refinements may often be omitted without affecting the utility of the structure and thereby not unnecessarily adding to its cost. Every dollar that is put into an engineering project is in the nature of an investment, and as such should yield at the earliest possible date a substantial return to the investor. This rule holds true whether the funds are furnished by municipalities, corporations, or individuals. Results are what count in the long run, and these results are often judged by the financial returns they produce.

To be successful, the engineer must produce results that are satisfactory to his clients or his employers, as the case may be. He may judge his success by the size of the income it yields to him in dollars and cents, or by his status in the engineering

world, measured by the amount of respect and praise that his professional brethren bestow upon him. For a time, he may be satisfied with the knowledge that he has carried to completion important engineering undertakings and practical designs, for which he may, or may not, receive his just share of praise and glory. Sooner or later, however, the vital need of satisfactory monetary returns for his labor and expenditure of mental energy will present itself, as it does to every man in pursuit of a livelihood, whether he follows a profession or not. A family cannot be supported and raised on mere praise and glory.

The commercial side of engineering is therefore an important one and should not be overlooked; especially while the future engineer is a student at school. A course of business and administrative methods will be of great value to him in the practice of his profession. The engineer should not give all his thought and time to pure technical matters, but should look around him and devote some time to a study of the business side of his profession. Too many men do not succeed in engineering because they fail to realize the importance of this, or do realize it when it is too late to turn back and start again.

Only a short time ago it was claimed that few university trained men were at the head of business enterprises and that the highest and best paying positions were held by men trained in the school of practical experience and having little, if any, advanced technical education. While statistics have proved the contrary, it is true that many so-called self-made engineers occupy executive positions and draw larger salaries than do the technically trained men working under them. It is not difficult to understand why this is so when we stop to consider that the self-made engineer gets his training in the school of practical experience, and from his very start learns the importance of the commercial side of engineering. The question of earning a living is an important one with him, for as a rule, such a man has not the means to enable him to attend a technical school. What theoretical knowledge he does obtain, he usually gets by attending evening classes or by home study.

When, on the other hand, the university trained engineer starts out in the world to practise, he has yet to secure the

practical and commercial experience which his competitor already possesses. Thus the self-made engineer has at the start an advantage over the technically educated one, and he knows that what he lacks in theoretical knowledge can be supplied by men whom he employs, men who often do the real work for which he takes the credit. Does it not follow then, that for his own success, the engineer should attach as much importance to the commercial as he does to the technical side of his profession? Is he not, like other men, entitled to the fruits of his labor?

Professional men often ask themselves why they are so poorly paid in comparison with men employed in business pursuits of life, and why a profession which requires not only expert knowledge and a high order of intellect, but also years of experience to be able to apply this knowledge correctly, yields as a rule less than do other means of livelihood which do not require such mental development and study. An analysis of the subject will show that so long as the professional man is content to apply his technical knowledge without regard to the commercial aspect of his profession, just so long does he remain the employee of the capitalist, and as such is but a skilled mechanic entitled only to the wages of such a man.

If, on the other hand, he considers in the application of his knowledge, the questions of cost and profit, his value increases because he works to the important interest of his employer. Should his employer not give him the proper remuneration for such work, he may sooner or later enter the business field of his profession equipped with proper business knowledge and become himself an employer; when his success will then in a large measure depend upon his individual efforts.

The commercial side of engineering has also its temptations and is not devoid of unscrupulous methods practised by men without honor and self-respect. Universities aim to instil the highest ideals into the minds of their students during a period when their characters are being formed, when their knowledge of the business world is often quite limited. These men start out in their careers only to have many of these ideals shattered, and to find the general business morals not so pure as they conceived them to be. This is a critical period in the professional life of the

engineer. If he is not strong-willed, courageous and faithful to the precepts of the teachings of his alma mater, he may yield to temptation and use as a means to financial success methods not sanctioned by a pure conscience. Hypocrisy is often mistaken for shrewdness, and lack of self-respect may sometimes be considered as diplomacy, but success gained by the use of such methods is not worthy of the name.

There are times in everyone's life when temptation is put in his path, but is it not better to feel that we have not wilfully wronged anyone, than to go to our graves knowing that we have won a so-called success at the expense of others, by sacrificing the welfare of our fellow men for our own individual ends? Above all, the engineer should be a man, honest with himself and true to his convictions.

It is questionable whether any other profession is made up of a more honest, conscientious and self-sacrificing body of men, and while there is no established written code of ethics, it is seldom that a recognized engineer of standing deliberately transgresses the unwritten moral laws of his profession. It is just as true now as it ever was that successful results can be obtained in business by the use of honorable and fair methods, and there should be no reason for the use of any dishonest or unfair methods in the business of engineering.

AN UNDERGROUND LIMESTONE QUARRY

C. M. WELD, '97, AND F. U. HUMBERT, '05

Two of the blast furnaces of the Low Moor Iron Company, of Virginia, are situated at Low Moor, on the Chesapeake & Ohio Railway, in Alleghany County, Virginia. These furnaces derive their flux from a so-called "quarry" lying a short half-mile to the south, and reached by the Low Moor Company's private standard-gauge railroad.

When this quarry was first opened up, the stone was won by ordinary open-cut methods. It is now many years, however, since the cover became too heavy for profitable stripping, and underground work was resorted to. Nevertheless the operation continues to be known as "the quarry," partly no doubt from force of original habit, and partly because it is a shock to one's sense of propriety to speak of a limestone "mine."

The bed of stone which is being thus mined is from 35 to 50 feet thick and lies nearly flat, dipping at a very gentle angle towards the N N E. Its crop-line is exposed along the S E flank of a hill, gradually descending below the water level of a neighboring creek. The approximately horizontal position of this bed is a local phenomenon, occurring in a region where the measures are for the most part tightly folded into a succession of N E-S W troughs and arches of the usual Appalachian type. The limestone is overlaid by 15 to 18 feet of sandstone, which in turn is overlaid by a great thickness of slates. Underneath the pure limestone is a cherty limestone, unsuitable for flux.

The overlying slates belong to the Romney shale, and occur at the base of the Devonian. The sandstone is Oriskany. It is believed that the limestone should also be classed as Oriskany, though government geologists would appear to group it with the underlying Lewistown measures. Discussion of the particular geological horizon to which the limestone in question should be referred is, however, foreign to the purpose of the present paper, as it is our intention to describe the mining methods which are in use, and some of the results which are obtained.

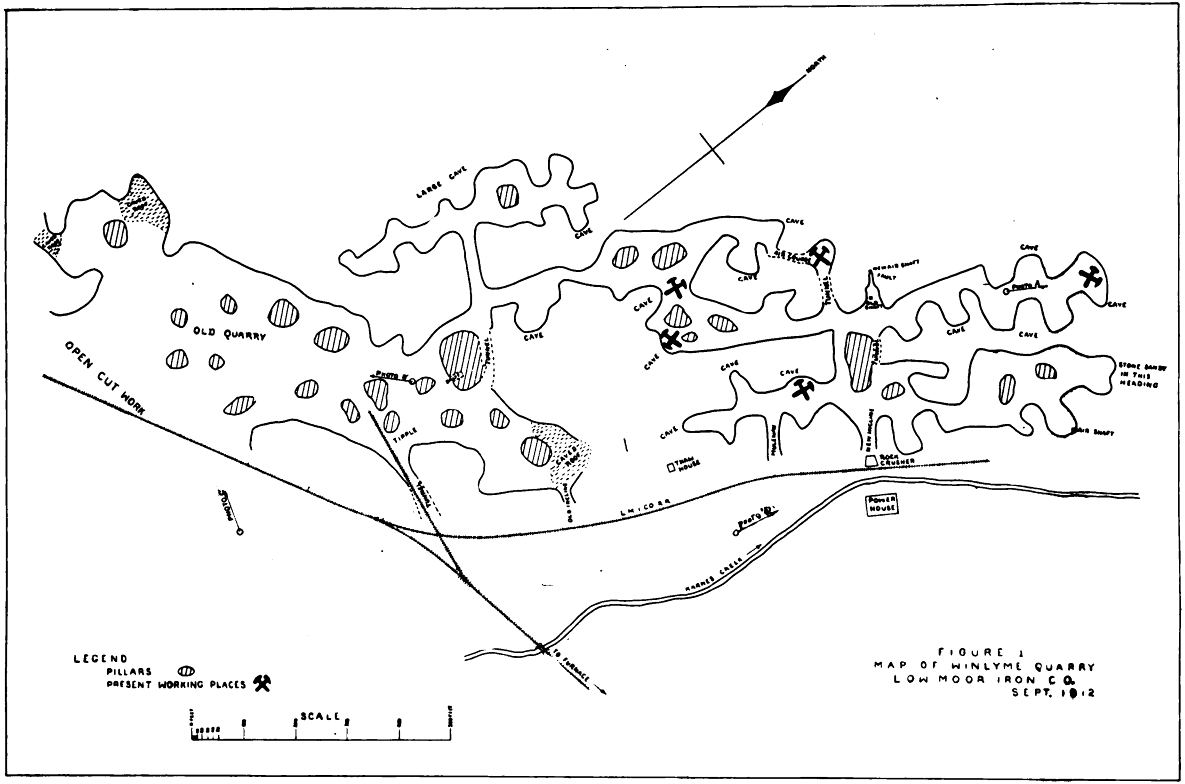


FIGURE 1. *Map of Winlyme Quarry, Low Moor Iron Company*

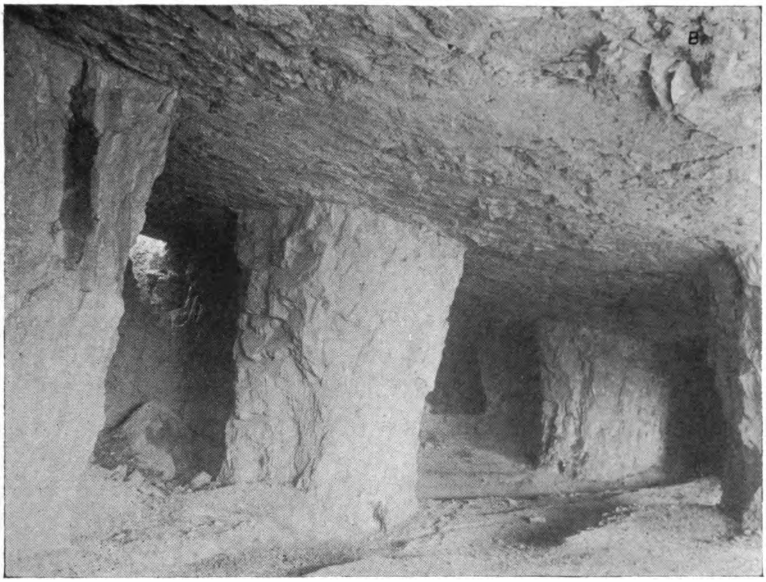
Method of Working:

Figure 1 represents a plan of the quarry workings as they exist today. The location of the original open-cut work is seen at the S W end. Underground work was first undertaken from the face of this open-cut (*see frontispiece*), but soon after a tunnel was driven in on the strike of the bed from a point about 400 feet to the N E and to the dip of the earlier work. Subsequently, with the continued extension of the work, two more openings were successively made, each one lying to the N E of the last and therefore always further to the dip. Since the last two were at points where the floor-level of the stone lay below the creek-level, short inclines became necessary. The incline furthest to the N E is the present scene of operation.

For extracting the stone, a general room-and-pillar method has been adopted. Two features govern and modify the practice of this method: — (1) The overlying sandstone forms ordinarily a wonderfully strong roof, for spans of 50 to 60 feet, and the limestone separates readily from this roof along a well defined plane of contact. (2) The limestone is full of caves which meander about with little system, generally at the top of the bed; when these are encountered, not only is there frequently much mud to handle, but the sandstone roof becomes insecure.

Therefore, under normal conditions, great galleries can be driven through the stone with rooms branching out of them, from 50 to 60 feet wide, and the full thickness of the stone in height; not a stick of timber being used for support. Very frequently, however, these galleries run into caves; sometimes so small that they can be safely crossed, at other times making it economically necessary to abandon the heading and turn in some other direction. With these conditions in mind it will become easier to understand the incompleteness, as it were, of development along room-and-pillar lines seen in the mine-map. It will be readily gathered that the supply of stone is exceedingly abundant; the object, therefore, is not to conserve it, but to win it at the least possible cost, so the quarryman avoids costly ground, continually turning to that which is easiest.

In short then, while we may say that the method is one of room-and-pillar, the result is an irregular system of galleries, really huge tunnels, with short branches. In some parts of the earlier workings, at the S W end, it was possible to block out comparatively large areas and even proceed to some extent with pillar-robbing (see Photograph B). The later work has been, and is now, essentially tunnel-driving on a large scale.



Photograph B

Drilling and Shooting:

All drilling is done with Ingersoll-Rand Little Giant D. M. No. 5 3¼ in. rock-drills, operated by compressed air at about 75 pounds pressure.

In driving one of the galleries, a first cut or horizontal slice is taken next to the sandstone roof, for a height of about 6 feet and for the full width of the gallery, this being usually from 50 to 60 feet. This is called the "heading" cut. To win this stone, eight-foot horizontal holes are drilled in vertical sets of three each, alternate pairs of sets converging towards one

another. Thus each pair, including two upper, two breast, and two dip holes, work on a flat-diamond shaped "lock" of stone, as shown in the plan, Figure 2. In this plan it is assumed that the present face is represented by the solid line. The eight-foot holes, in vertical sets of three each as described above, are drilled along the dotted lines outlining the "locks" marked 1. The rib holes, on the right and left extremes of the "heading," may be only 6 feet deep. When these holes have been shot, the face will have advanced to the dotted lines surrounding the

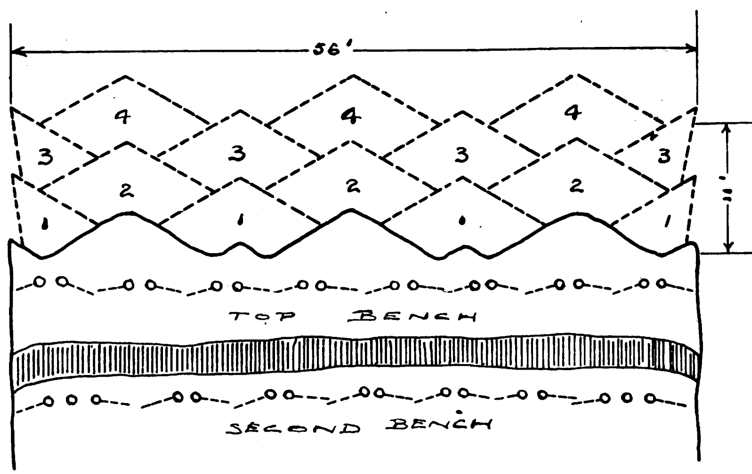


FIGURE 2

Plan, showing arrangement of locks in heading cut, and of drill-holes on benches

"locks" marked 1, and new holes are drilled in the same manner along the dotted lines outlining the "locks" marked 2. Next the "locks" marked 3 are drilled and shot, and so the "heading" progresses, always presenting a serrated face to work upon.

As the "heading" advances, it leaves behind it the "top bench." Below this are two or more lower benches, as seen in the section, Figure 3. Along each bench and close to the back are drilled rows of holes, generally in pairs and diverging slightly, also leaning slightly outwards. The section, Figure 3,

is an idealized representation of the present conditions at the northernmost working place in the quarry, where the stone is nearly 50 feet thick. It will be seen that four benches are worked, these being 8, 10, 12 and 12 feet high respectively from top to bottom. The holes are drilled to the full depth of the bench, and some 7 or 8 feet back from the face. The pairs of holes are placed at 7 to 8 foot centers. Along the floor it is

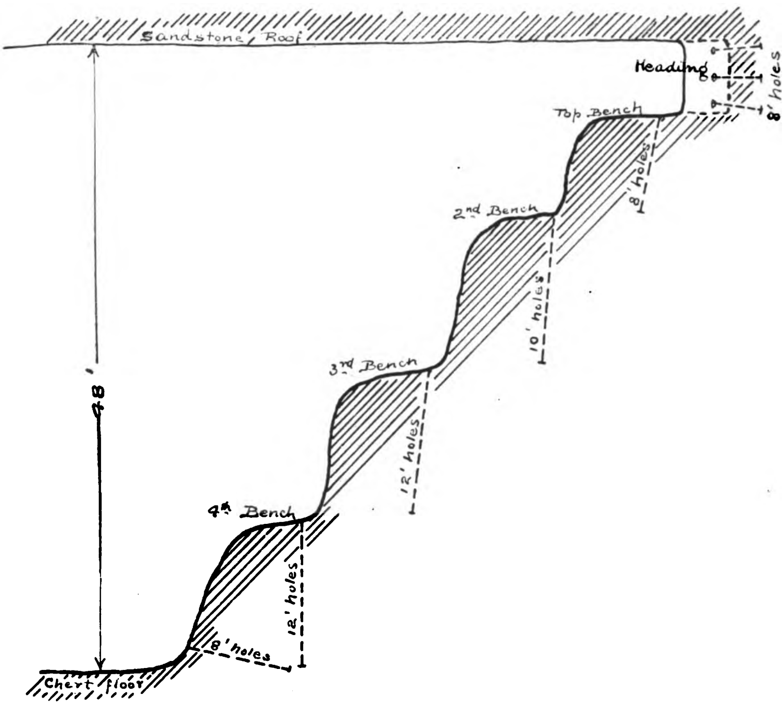


FIGURE 3

Longitudinal vertical section at face of gallery, showing arrangement of drill-holes

frequently necessary to place a few additional toe-holes or lifters about 8 feet deep.

Since each round of holes in the "heading" advances the work only about 2¾ feet, it is necessary to drill and shoot the "heading" an average of nearly three times for each time the benches are shot.

It will be understood that the diagrams presented in Figures 2 and 3 are ideal, and represent theory rather than practice, since it is rare that the entire face of the gallery presents stone so homogeneous in texture as to break infallibly along predetermined lines. That practice approaches theory in its results is shown, however, by the following figures.

To advance the gallery 7½ feet, theory tells us that we must shoot the "heading" 2.7 times, and the benches once. With a face 56 feet wide and 48 feet high (as shown in the diagram), a 7½ foot advance should produce 1550 tons of stone (at 13 cu. ft. to the ton of stone in place). Of this, one-eighth, or nearly 200 tons, would come from the "heading" cut. The theoretical drill-feet required for this work would be:—

	Drill-feet	*Tons of Stone*	*Feet per Ton*
"Heading" holes	450	200	.21
Benches and toe-holes	800	1350	0.59
Total	1250	1550	0.80

The actual average drill-feet per ton of stone for the months October, 1911, December 18, 1912 inclusive, was 0.87, as against the theoretical 0.80 shown above.

Drill-labor, including smithing, costs slightly over 30 cents per drill-hour and the average speed is 5 feet per hour. The cost per foot is therefore 6 cents, and the cost per ton of stone about 5¼ cents. The actual cost is about 0.4 cents per ton of stone higher than the theoretical cost.

All blasting was formerly done with straight 40% nitro-glycerine dynamite. When the price of glycerine advanced in the spring of 1911, tests were made with ammonia products, and as a result a dynamite was adopted containing only 17% nitro-glycerine, in combination with 50% nitrate of ammonia. This material has given good satisfaction, and explosives costs have been actually a little lower than they were before the price of glycerine advanced.

When the drill-holes have been thoroughly blown out and cleaned with compressed air, they are loaded with from 10 to 18 sticks of dynamite each, according to their depth and situa-

tion. Six and eight-foot electric exploders are used, provided with a No. 6 cap. Firing is performed by means of an electric battery, each bench being shot separately, from bottom upwards.

The ammonia dynamite is of low specific gravity, and therefore bulky, running about 130 8 in. by 1¼ in. sticks to the 50 lb. box or roughly 0.4 lb. per stick. We consider this feature to be advantageous in our case since a definite weight of charge is thereby distributed over a greater length of hole, and a stronger shattering effect is produced. It is essential not only to bottom the holes but also to break up the stone into reasonably small fragments. As it is, a large proportion of lumps have to be subsequently block-holed, at the expense of further ammunition. The block-holing is done with a Sullivan "D B-19" hammer-drill.

For the same period referred to above, namely October, 1911, to December 18, 1912 inclusive, the consumption of dynamite per ton of stone has averaged 0.77 lbs. Of this, 0.61 lbs. has been used in shooting holes and 0.16 lbs. in block-holing lumps. The "heading" stone consumes far more dynamite than the "bench" stone, the ratio being 3½ to 1, or about 1.60 lbs. and 0.45 lbs. respectively. It becomes evident that by far the most costly part of our work, as regards both drilling and shooting, is the removal of this first slice or "heading" cut immediately below the roof. When this has once been done the benches come out readily except against the ribs.

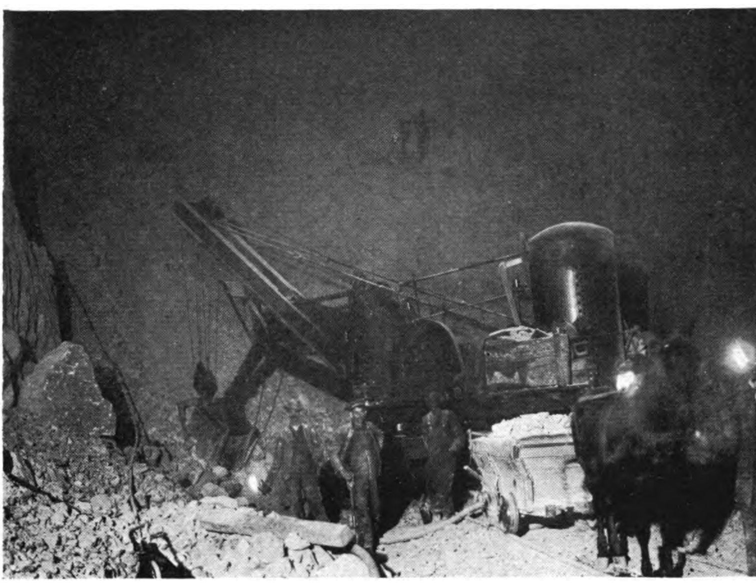
Dynamite freezes at 45 degrees Fahrenheit. A concrete thaw-house, provided with a small steam radiator, has been recently built. Here a temperature of 55 degrees to 80 degrees is maintained, as recorded by a maximum and minimum thermometer. This thaw-house holds about 15 days' supply. As quickly as dynamite is removed from it for use, it is replaced by fresh dynamite from the main magazine. Thus an ample supply of thoroughly thawed dynamite is always on hand during the coldest period of winter, while at the same time it is never subjected to a temperature which may promote decomposition.

Loading:

The stone is loaded partly by hand and partly by shovel. Some hand work is always necessary for cleaning off benches

and for scrapping up the scattered stone as well as the last remnants from each shot.

Hand-loading is paid for by piece-work. Two men are assigned a working place where there is a supply of well-broken stone, and are furnished with cars as they require them. They are paid 10½ cents per car, the average content per car being 1⅜ tons of stone. Thus hand-loaded stone costs 7.6 cents per ton. The men use shovels, and will load from 15 to 17 cars per man per 10 hour shift, sometimes more.

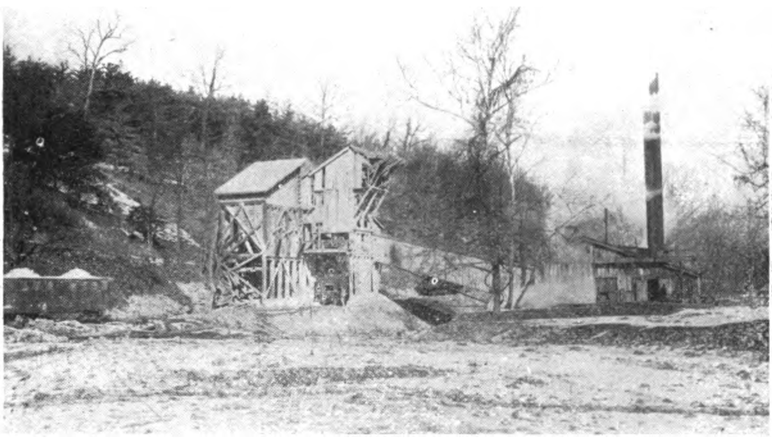


PHOTOGRAPH A

The shovel is a Thew Automatic, No. 1 Type, full circle swing, provided with a one-yard dipper. It is operated by compressed air, the air consumption, at 75 pounds M. E. P., being from 650 to 750 cubic feet per dipper. Two dippers fill a 1½ ton car. With an ample and well-broken supply of stone ahead, this shovel easily loads 20 cars per hour. There are many unavoidable delays, however, and 200 tons is about an average day's work. Labor cost for serving the shovel is $6.20 per day. (See Photograph A).

Hauling and Hoisting:

Hauling is performed by mules, handling one car at a time. The average distance from working-place to foot of incline and return is 1100 feet. Grades about balance one another, there being a slight grade in favor of the load from the south-west places and the same against the load from the north-east places. There have been handled recently an average of 53 cars per mule-day. The usual average is about 40 cars.



PHOTOGRAPH D

The tracks are well laid, with 35 lb. steel at 36 in. gauge. The cars are of wood, with swinging doors at the back.

As the cars reach the foot of the incline, or "dock," they are coupled to a steel rope and are pulled to the top of the tipple, where they are dumped into a bin, leading to a 36 in. by 18 in. Farrel (Blake pattern) jaw crusher, set to crush to 4 inches. The crushed stone is screened before entering the railroad car over a steel plate perforated with 3/8 inch round holes. The resulting limestone dust, amounting to about 3½% of the total

output, is elevated to storage bins, whence it is later drawn off into separate railroad cars, and shipped for concreting work or agricultural purposes. The crushed and screened stone goes to the blast furnace for flux. The rock crusher and the power house are shown in Photograph D.

The incline is 123 feet long. It is double tracked, the cars working in balance, and is operated by a Lidgerwood duplex 7 in. by 10 in. reversible hoist with 26 in. drum.

The Power House:

Besides the hoist just described, there are two compressors, one Sullivan and one Laidlaw-Dunn-Gordon, with a total capacity of 1026 cubic feet of free air per minute; also a 14 in. by 18 in. simple side crank Virginia Machine Company engine, 140 R. P. M., for driving the crusher and other tipple machinery. Steam is raised in two return tubular boilders, one Virginia Machine Company, 66 in. by 16 in., and one Earle C. Bacon, 78 in. by 16 in.

Miscellaneous:

Ventilation is natural and ample at all times.

There is practically no water in the quarry. In the summer months the roadways become muddy from the precipitation of moisture out of the warm incoming air. During the winter the conditions are reversed and these same roadways become dusty. A pump is stationed at the dock and has had to be used on one or two rare occasions when cloud-bursts have caused temporary floods. Otherwise it stands idle.

Lights are furnished free to the miners and consist of kerosene torches. In addition there are two acetylene lamps, one 3000 C. P. and one 500 C. P., used in connection with the shovel work. The cost of lighting amounts to about $40.00 per month.

General:

The present output of this quarry is from 5000 to 6000 tons per month. The total output from the beginning of operations has been approximately 1,665,000 tons.

The quarry Superintendent is required to fill out and send in promptly a report of each day's work on the form shown herewith (see Figure 4). By this means the general office is able to keep in close touch with the progress of the work, including the current labor cost, the work of the drills, the con-

The Low Moor Iron Company of Virginia
SUPERINTENDENT'S DAILY REPORT

LIMESTONE QUARRY, Low Moor ______________ 191__

LABOR REPORT

	DAY		NIGHT		Total Cost	Cost per Ton
	No.	Cost	No.	Cost		
GENERAL						
Superintendence						
Foremen						
Blacksmiths						
Blacksmiths' Helpers						
Engineers						
Firemen						
Crusher and Tipple Men						
Miscellaneous						
Total						
DRILLING AND SHOOTING						
Drillers						
Drillers' Helpers						
Tool Carriers						
Pipe Fitting						
Shooting Gang						
Total						
LOADING						
Steam Shovel						
Operator						
Crew						
Dropping Cars						
Hand Loaders						
Total						
HAULING						
Dock men						
Switchmen						
Track Gang						
Car Repairs						
Drivers						
Mules						
Total						
Grand Total						

Grand Total Cost to Date	
Estimated Tons Stone to Date	
Average Cost per Ton to Date	

DRILL REPORT

	TO-DAY		TO DATE	
	Day	Night	Day	Night
Number of Drills				
Total Drill Hours				
Total Feet Drilled				
Average Feet per Hour				

EXPLOSIVES REPORT

	TO DAY	TO DATE
Dynamite – Lbs		
Shooting Holes		
Dobying		
Total		
Average Lbs per Ton		
Fuse		
Caps		

OUTPUT REPORT

	RATE	TO-DAY	TO DATE
Steam Shovel			
Hand Loaders			
Contractors			
Total Tons			
No. of Cars to			

REMARKS
(Report Delays with causes, Accidents, Special Work, etc.)

____
Superintendent

FIGURE 4

sumption of explosives, and the output of stone. Under normal conditions of working and with the present out-put, the following is a typical cost per ton of crushed and screened stone into railroad cars: —

Superintendence	$0.03
Labor	0.23
Explosives	0.09
Fuel	0.04
Supplies	0.03
Total	$0.42

Better than this has been done from time to time, particularly when a higher output has been demanded, and we believe that some permanent reductions from the above should be made. In criticising these figures, however, the tunnel-driving nature of the work should be kept in mind.

SHEARING STRENGTH OF JOINTS BETWEEN OLD AND NEW CONCRETE AS SHOWN BY TESTS

JOHN R. NICHOLS, '06

Instructor in Civil Engineering, Harvard University

In reinforced concrete floor construction it is common practice to stop work at the end of the day at the middle of the span of slabs, beams, and girders. A vertical bulkhead or dam is erected on the forms for the purpose, and is taken down the next day when work is to be resumed. Thus there is formed a construction joint between old and new concrete.

The reason for placing this joint at mid-span is that nowhere else, in most cases, is the shear so likely to be a minimum except over a column where, for various reasons, such a joint is undesirable. For uniform loading the shear is zero at mid-span, but of course uniformity cannot be counted on and the shear may rise as high as one quarter the maximum live shear at the end of the beam, or more in special cases.

The writer knows of no tests made to determine the strength of such a joint in shear up to December 1911, when the question of the strength in shear of a horizontal construction joint between the stem and flange of a T beam was referred by a Boston contracting firm to Professor L. J. Johnson for solution. A series of tests of reinforced concrete beams was undertaken at that time to assist in answering the question. The results of these are fully reported in the Proceedings of the American Society of Civil Engineers for February, 1913.

At the same time two other tests of a different nature were made with the same object in view. It is the purpose of this paper to describe briefly these other tests and report the results thereof. They consisted, one of pushing a conical plug large end first out of a surrounding ring or casing, the other of crushing a prism with a sharply inclined joint,—the plug being cast a week later than the ring, and the upper part of the prism some days after the lower part.

For the first of these tests, three concrete rings were cast 8 inches thick, each with a tapered hole 8 inches in diameter at the top and 8¼ inches at the bottom. The cores for the holes were of wood, turned in a lathe and finished with shellac. Notwithstanding the smoothness of the cores, the concrete surface of the holes was somewhat rough, due to leanness of the concrete mixture, and to abrasion occasioned by withdrawing the cores. The rings were reinforced with three steel hoops.

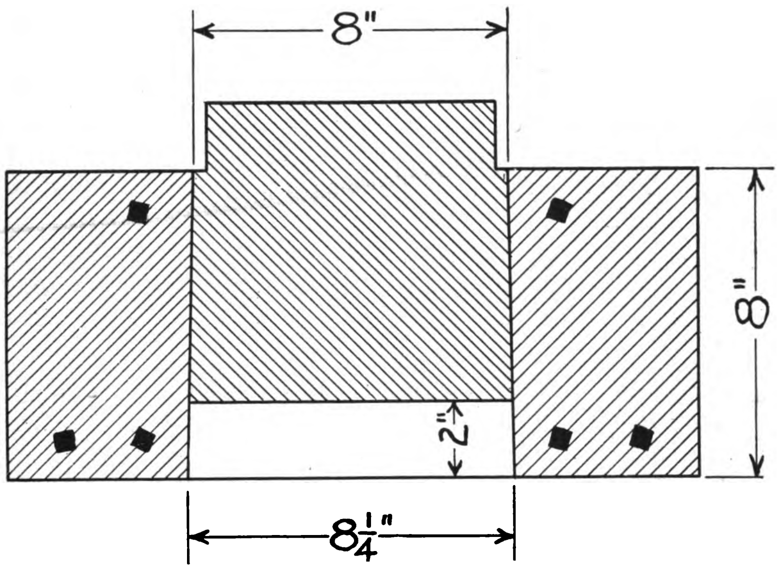


FIGURE 1. *Vertical Cross-section through Ring and Plug*

When the rings were a week old they were inverted and placed on 2-inch planks in which circular holes 7½ inches in diameter had been cut. The holes in the rings were made concentric with those in the planks. The planks rested on the floor. Concrete was then poured in to within two inches of the top, and was carefully tamped. Thus a plug 8 inches long was cast in each ring, projecting two inches at the smaller end and lacking two inches of filling the hole at the larger end. A vertical section through the center of the completed specimen is shown in Fig. 1.

The specimens thus prepared were placed at various ages in the testing machine in the position shown and the plugs pushed out. The strength of the joint in bond-shear is measured by the load required to start the plug.

The numerical results of this test are presented in the following table: —

No. of Specimen	*Age of Ring (days)*	*Age of Plug (days)*	*Total Load (lbs.)*	*Unit Bond Shear (lbs. per sq. in.)*
1	35	28	122,000	800
2	14	7	92,400	605
3	21	14	90,200	591
			Average	665

The unit shear is computed on the assumption that the intensity is uniform over the area of the plug in contact with the ring. The maximum intensity was certainly not less than the value thus obtained, and was probably much greater.

The load required to start the plug was the maximum reached, but the frictional resistance remained high, after the plug started falling off slowly as the motion proceeded.

The other test was of two 5 in. by 5 in. by 10 in. compression prisms. The forms for the prisms were first tilted over to within about 30° of the horizontal and filled half full, the top of the concrete remaining level. The top surface was fairly smooth.

Four days later the forms were righted and filled up. The result was a prism with a diagonal joint as shown in Fig. 2. The surface of the old concrete was not scraped or otherwise treated in any way before placing the new.

The specimens were placed in the testing machine and a load applied longitudinally, as in a compression test.

Both specimens broke at the joint suddenly with a report, one at a load of 26,200 lbs., the other at 33,700 lbs. The ultimate unit bond-shear is computed to be 496 and 621 lbs. per sq. inch, respectively. The break on the joint was clean, no signs of abrasion appearing on the surfaces.

Conclusions:

While these tests are hardly numerous enough to warrant any sweeping conclusions, they at least tend to show that the shearing stress on a construction joint between sections of concrete cast at different times, the newer concrete cast in contact with the older, may easily reach 500 lbs. per sq. inch without yielding, even when no reinforcement crosses the joint. How high a shear the joint can resist with reinforcement to hold the two parts together, is yet to be determined by tests. It may reasonably be expected to reach a higher value than that attained in these tests, though even here the pieces of concrete connected

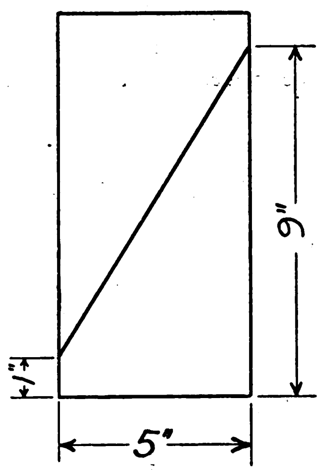


FIGURE 2. *Side Elevation of Prism, Showing Diagonal Joint*

by the joint were to some extent prevented from separating. In the case of the rings and plugs, the shape of the specimens precluded any substantial tension on the joint, and with the prisms the component of the load normal to the joint induced compression.

The value for the bond shear reached in these tests, however, is high enough to warrant the placing of a vertical construction joint in the middle of spans where the unit shear would seldom exceed 25 lbs. per sq. in., and never 100 lbs. per sq. in. in a floor designed in accordance with present accepted practice.

SOME REMARKS ON A CENTRAL COLLEGE LIGHTING PLANT

LEAVITT C. PARSONS, '10

In a recent number of one of the college publications* the writer endeavored to show the economies involved and the improvement in the service rendered if Harvard College undertook to manufacture and distribute electric current for its own needs. As the Yard is practically an independent tract, it was taken as a specific illustration for the suggestion, and the general problems treated were confined to that area. Before taking up some of the more technical features it might perhaps be well to run over this original argument and then examine the changes that will be necessary in the present lighting and heating layouts.

Both gas and electricity are now bought by the college in large quantities for use in the Yard. Last year about 4,000,000 cu. ft. of gas were consumed in illuminating the grounds and buildings in this area. The cost of this, which was defrayed in part by the students, was approximately $3,500, or about equal to the cost of electricity purchased for light and power during the same period All of this money went to the Cambridge gas and electricity companies.

The Yard heating plants operated in University and Sever Halls, cost the college from $15,000 to $16,000 per year for fuel and maintenance. The new chemistry laboratories will take some of the classes from Boylston Hall, and these two boiler plants could be combined and placed in that building. By installing a power plant in connection with the heating plant, large economies could be effected, as the steam which is now used but once, could be used twice. That is to say, steam at high pressure could be used in the generating unit, and the exhaust steam could be used for heating the college buildings.

A second unit generating plant was suggested for Holmes Field to supply current for all the lecture halls and dormitories

* The *Harvard Illustrated Magazine* for March.

in that vicinity, including Conant Hall and the museums across Oxford Street. Counting the residences of members of the faculty, there are over twenty-five buildings that could be connected to this plant. A scheme was also outlined for installing and operating these plants by means of a corporation organized by officers of the University, the entire stock of which would be owned by the college through its various funds. All savings in operation like the above mentioned expenditures for gas and electricity would then accrue to the college either through dividends or as an improvement in the service rendered. In other words, Harvard would have capitalized her lighting and heating business.

A consolidation of the college lighting and heating business is certainly economically logical, and there are no insuperable technical difficulties. At present only a few of the Yard buildings are wired for electricity, so there would be considerable additional expense incidental to the change from gas. These costs, however, have been considered in the financial plan and need not be discussed here. All the college dormitories are lighted by gas both in the Yard and on the Holmes Field tract, though Walter Hastings has electricity in a few rooms. The Law School buildings use electricity and a part of the University Museum is wired. All the current used here is bought, though there are two electric generators in Pierce Hall that make electricity to run some of the apparatus there and to supply low voltage lines for operating stereopticons in the adjacent buildings.

The present system of lighting the Yard is as illogical as it is ineffective. The equipment consists of old-fashioned gas lamps of rather limited candle power on the corners of some of the buildings, though the Cambridge Gas Company has recently installed for trial some high power lamps. The night watchman's work is made difficult for the lack of a systematic arrangement of the lights. The brilliant glare of large lamps is not desirable, but by placing small electric lights over the gateways and in each of the dormitory entries and other lamps at turns in the roadway a greater service could be rendered those who use the Yard at night. An excellent gift for some

class returning for its twenty-fifth anniversary would be a new equipment for lighting the college grounds.

Compared with the lighting, the power demands of the college are not very heavy. The University press under University Hall is run on a 500 volt D. C. system connected with tne Cambridge Electric Company. The only other power used in the Yard is for ventilating fans and some laboratory apparatus. There is a fair demand for power for apparatus in the buildings of the engineering group, but most of this is supplied from Pierce Hall. With the removal of the boiler plant to Boylston Hall the space formerly occupied in University could be taken over by the college printing office. New presses could be added and cheap power taken from Yard plant. A more complete system of ventilating fans could be put in and run from the same source. The day load would be further filled in by a large number of electric lights that would be burning all the time in basements and hallways. Many dark offices and parts of the library reading rooms would also require light in the daytime.

The Yard, as we have said, is now heated from two plants. The University Hall plant is the larger and serves all the dormitories and adjacent buildings. The Sever plant heats that hall, Robinson and Emerson. There is a small generator attached to the Sever plant for operating the ventilating fans and stereopticons. The expense of changing over to a central heating plant would not be excessive, as the present system of piping with a few slight alterations could still be used. The new library will serve as a valuable part of a pipe line between Boylston and Sever.

In considering the equipment of the generating plant itself several important points must be borne in mind. Chief among these is the fact that to be efficient unit plants such as suggested must be very centrally located. In this case they must also be of such construction as not to offend the eye by their appearance or create a nuisance by their operation. The most suitable location for the Yard unit would probably be on the site now occupied by a sunken laboratory in the rear of Boylston Hall. This would necessitate no greater inconvenience in securing the fuel supply than under the present system, and is near enough

to the trolley tracks to allow the possibility of receiving coal in carload lots. The boilers and generator could be housed here in a low-roofed structure so designed that few would suspect it was a power house.

Taking up the generating equipment, it is estimated that a 500 K. W. generator would supply the heaviest load demands for lighting the Yard buildings and the grounds. A turbine would probably prove more satisfactory than a reciprocating engine because they generally run quieter. A set of Babcock & Wilcox boilers would give the best service for the limited space available. The old fire-tube boilers in the University Hall plant could not be used as they are for low pressure work only.

In order to minimize the smoke nuisance it might be well to install some sort of a mechanical stoker, even though it would seldom be done for purely economical reasons in so small a plant. The inartistic appearance of a chimney could be avoided by running a square steel stack up the side of Boylston Hall, and a satisfactory draft could be insured by equipping this with a Sturtevant blower.

The second plant could probably be installed with but slight alterations in one of the present buildings in Holmes Field group, thus avoiding the greater expenditure of erecting a new building. This would have about the same capacity as the Yard unit and would be connected with it by an emergency conduit, so that one plant could look after all the work if the other was temporarily disabled. A switch to the Cambridge Electric Company would allow the purchase of the small amount of current required in the summer when the plant could not be operated at a profit.

The cost of installing an electrical generating plant of the type described is estimated at about $80.00 a K. W., which would make the cost of the Yard plant approximately $40,000. A second plant of the same size would double this amount, and if the burden of completing the wiring were assumed by the new corporation, roughly $20,000 more should be added. It would therefore be necessary to raise about $100,000 in order to install and equip a competent college heating and lighting plant.

We have so far failed to mention an important question, the neglect of which makes so many small electric plants uneconomical. This is the diversity factor. With a college plant such as we have described the peak would come sometime after supper when the greatest number of lights were going. The normal day load would be low for the power demand is relatively small. Nevertheless, the plant would always have to stand ready, for, as not infrequently occurs, the passing of a particularly dark cloud across the sun will mean the immediate switching of some thousands of lights in the lecture halls and in the various college reading rooms.

The day load for the college plant could be filled in a little more by connecting up with the Union across Quincy Street where there are always a number of lights burning all day and where the Crimson Press would allow the sale of some surplus current. The Yard service might also be extended across Massachusetts Avenue to Holyoke House. In this case, however, the unbalanced demand for electricity would be to a large extent offset by the fact that the heating business will be carried on in conjunction with it and one line may be considered to be a by-product of the other. The real economy is in their combined operation.

It is understood that the college is contemplating some rearrangement of the present heating system, and it will be interesting to observe how far the attempt to consolidate all the lighting and heating business is successful. The opportunity is obvious, and however far they go the results should tend towards greater operating economy.

ENGINEERING AS RELATED TO THE INCANDESCENT LAMP INDUSTRY

ROSCOE E. SCOTT, '07

The average college man, when he thinks of electrical engineering as related to manufacturing, thinks of shops choked with turbines, railway motors, big transformers, and other heavy apparatus, with perhaps a vision of high tension tests conducted on 6-foot spark gaps. This is a very one-sided view. Good solid engineering work is being done incessantly in connection with the manufacture of the less spectacular apparatus, including incandescent lamps, to which the writer would more particularly refer. When it is considered that one of the chief *raisons d'être* of heavy generating, transmission and transforming apparatus is that energy must be supplied to millions of these unimposing bulbs, their real importance in the electrical industry becomes apparent. It is hoped that this article may serve to interest some of the Harvard undergraduate engineers in the field of incandescent lamp engineering.

Engineering work is divided commercially into four more or less closely related branches at the laboratories of the National Electric Lamp Association in Cleveland. These may be listed in the following order:

1. Engineering tests conducted directly on the product itself.
2. Research work.
3. Illuminating engineering.
4. Economics.

Let us look into these a little further.

1. Engineering Tests on the Product Itself:

These may be subdivided as follows:

(*a*) Life tests.

(*b*) Photometric tests of various kinds and interpretation of data secured therefrom.

(*c*) Special and miscellaneous tests, including tests on mechanical strength of bulbs, bases, etc.

(*a*) The life tests are in some ways the most interesting of any. At the Cleveland laboratories a large room, which, by the way, is located directly beneath the glass roof of the Engineering Building, is filled with fireproof racks so arranged that 10,000 lamps may be on test simultaneously for any desired length of time, at voltages ranging from 6 to 260, for the ordinary multiple lamps, besides which there are facilities for burning street series lamps at any commercial amperage and 500 "candelabra" and "miniature" sockets reserved for the testing of miniature and automobile lamps.

The racks upon which lamps are burned for life test have a capacity of about 10,000 sockets so wired as to provide practically all desired voltages. All alternating current sockets are supplied from auto-transformers of 0.75 kw. capacity; these transformers are required to pass an acceptance test showing a regulation from no load to full load of not more than one-tenth of one per cent. There are about 1200 of these transformers in use at the present time. The power for the racks is obtained from a sub-station, from which point both alternating and direct current are distributed to the rack rooms. The voltage regulation is kept between plus and minus two-tenths of one per cent. by means of Tirrill Regulators. If by any chance the voltage rises one volt the recording meter automatically sounds an alarm; a further rise in voltage throws the circuit breaker. The voltage is under the constant surveillance of the operator; hourly readings are recorded. As a further check, frequent readings of the voltage are made in the calibration room, without the knowledge of the operator.

Some idea of the appearance of the life racks may be obtained from the illustration. The auto transformers will be noticed along the base of the racks.

(*b*) Photometric measurements are made on three specially built photometers, each equipped with a Lummer-Brodhun contrast screen. Each determination is made by two different operators on different photometers. Current and voltage measurements are made by means of laboratory standard voltmeters

and ammeters, which are carefully calibrated at regular intervals. The current for each photometer is taken from its individual storage battery.

Not only are photometer tests made to determine the intensity and distribution of light from the lamps, but shades, globes and reflectors of all sorts are tested in combination with various lamps in order that data on the modified distribution of light may be obtained. As may be imagined, the interpretation of these data keeps a force of draftsmen and computers busy.

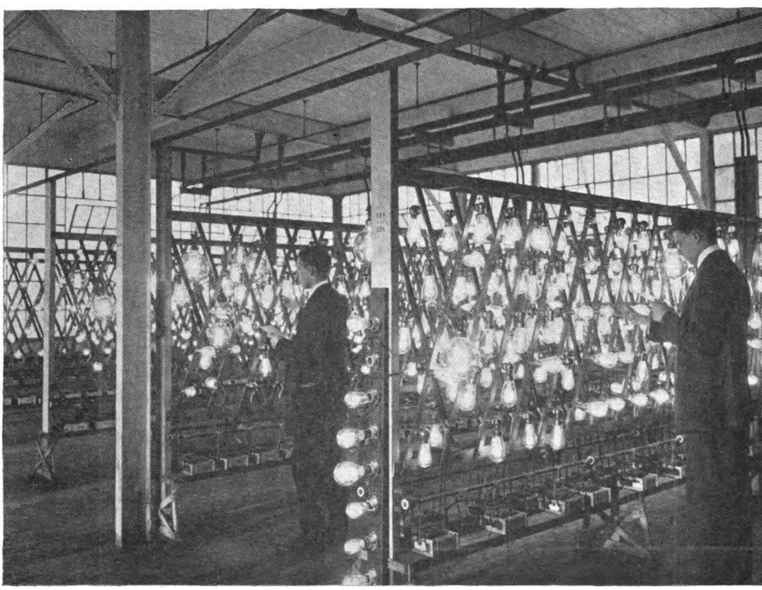


FIGURE I. *Life Testing Racks*

(*c*) The miscellaneous testing work includes the testing of lamps for various degrees of vacuum, measuring the torque required to wrench the base loose from the bulb, etc.

2. *Research Work:*

The research work conducted in a large incandescent lamp engineering department is of a very diversified character. To the research division are referred all problems requiring special in-

vestigation or the use of special apparatus. Often such investigations will require the design and construction of special apparatus, as in the recent building of a delicate machine to test the bending strength of tungsten filaments. A far cry from this to the steel-testing machines in Pierce Hall Laboratory! As

FIGURE 2. *Making an Illumination Survey*

another example of the work of the research engineers may be cited a recent test to investigate the effect of "concentrating" the filament used in automobile lamps, on the illumination produced at a distance of fifty feet from paraboloidal headlight reflectors.

Many of the men who take up either the lamp testing or the research work, above mentioned, will go into the manufacturing end of the lamp business and become assistant superintendents or managers of factories. Others go into the chemical or filament development laboratories connected with the manufacturing department. The men soon find the particular line of work to which they are individually adapted.

3. *Illuminating Engineering:*

Illuminating engineering is the third class of work which may be taken up by a technical graduate going into the lamp business. This class of work, it will be perceived, depends upon the testing work to a considerable degree for data on the characteristics of illuminants. The illuminating engineer must familiarize himself with the different uses and comparative merits of a thousand lamps and a thousand-and-one reflectors. His "dope book" therefore, is generally pretty well crammed with blueprints, tables, and reports. He is often called upon to take his portable photometer set, go to some large factory or railroad shop and conduct illumination surveys under actual working conditions. His duties take him out on the road more than those of the other engineers. Such work for a man of commercial instincts will lead to a position as sales engineer. The illustration shows a couple of engineers making an illumination survey in the corridor of a new office building.

4. *Economics:*

One of the most important functions of the trained engineer in the lamp business is to give advice as to the most economical efficiency at which lamps should be rated and burned. This entails study of central station costs, rates, lamp characteristics, and a great deal of mathematical work. As a rule, it is taken up only by men who have received an advanced degree in engineering, and such men as a rule remain in the purely technical end of the lamp business indefinitely. As an example of the kind of work undertaken by the engineers of the Economics Section there is reproduced in the accompanying illustration a

three-dimensional model, constructed to illustrate the cost of light in cents per one thousand candle-hours under varying conditions with a certain type of lamp.

In addition to its Engineering Department, one of the large American manufacturers maintains a physical laboratory for the investigation of abstruse problems in physics and light. This,

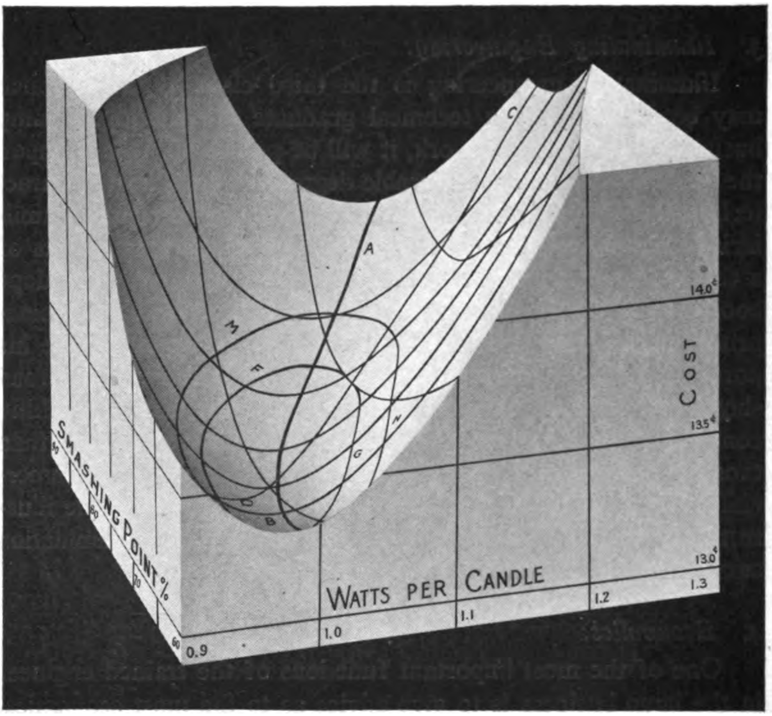


FIGURE 3. *Model Prepared by Economics Engineer*

however, is a field that appeals to the student of advanced physics rather than to the electrical engineer.

The source of supply for the trained engineers necessary to carry on the technical work of the incandescent lamp industry consists of the colleges and technical institutes. The incandescent lamp Engineering Department in Cleveland, to which I

have referred, has added during the last four years no less than 110 electrical engineers from American colleges and technical schools to its staff. Seventy-five per cent. of these men are still with the Company, a rather remarkable record for engineers just starting out. Only two of these men have come from Harvard, however, a disproportionately small showing, in the writer's humble opinion. It is to be hoped that many men who graduate this year will give careful consideration to this branch of engineering before making their choice of a position.

THE MYRIAWATT

ARTHUR E. KENNELLY
Professor of Electrical Engineering

On December 13, 1912, a joint meeting was held, in New York City, of Standards Committees from the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. The following resolutions were unanimously passed:—

"WHEREAS, the 'Myrowatt' or 'Myriawatt' was suggested by Mr. H. G. Stott, as a convenient unit of power, only 2% larger than the most recently determined values of the 'boiler horse-power,' and

WHEREAS, a paper setting forth the advantages of the use of the 'myriawatt' as a unit of power in dealing with the performance of steam boilers, steam engines, gas-engines, steam and water-turbines was read by Messrs. H. G. Stott and Haylett O'Neill before the Annual Convention in Boston, of the American Institute of Electrical Engineers, in June 1912, was discussed and was published in the Proceedings of the Institute, and

WHEREAS, the American Society of Mechanical Engineers has appointed a Special Committee to confer with the Standards Committee of the American Institute of Electrical Engineers upon this unit, as presented in the said paper, be it

(1) *Resolved,* that the two committees in joint session, recommend to their respective societies the use of the 'myriawatt' as unit of thermal or mechanical power, as indicated in the above mentioned paper.

(2) That the two committees also jointly recommend to their respective societies the exclusive use of the myriawatt in connection with boilers, producers, turbines and engines, and discontinue the use of the term 'boiler horse-power.'

(3) That Mr. C. O. Mailloux, as representing Mr. H. G. Stott on the Special Committee on 'Prime Movers,' recently appointed by the International Electrotechnical Commission,

which Committee is scheduled to meet at Zürich, Switzerland, on January the 18th, 1913, shall be, and hereby is requested to bring these joint resolutions formally to the notice of that body in Zürich.

(4) That the two committees jointly recommend that in writings and publications the 'myriawatt' and 'myriawatt-hour' be abbreviated to Mw. and Mwh., in conformity with the existing abbreviations Kw. and Kwh. for kilowatt and kilowatt-hour respectively."

The above resolutions were duly approved by the governing Boards of the two Engineering Societies.

The resolutions are of importance; first, because they embody the first piece of constructive standardizing work accomplished by the two societies through joint standardizing committees; second, because the introduction of the term "myriawatt" will greatly simplify engineering statistics and computations in tests of steam turbo-generators and other generator units. The prefix "myria" belongs regularly to the Metric system, and means 10,000, as in the term "myriameter," 10 kilometers, and the English word "myriad," meaning 10,000. The myriawatt happens to be very nearly the same unit of power as the "boiler horse-power," originally defined as the rate of steam power production corresponding to the evaporation of thirty pounds of water per hour from a temperature of 100° F., to the temperature of steam at 70 pounds pressure per square inch, and evaporated into steam at this pressure. In the efficiency tests of turbo-generator units, it is common to give the input power in boiler horse-power or in thermal units, and the output in watts. Under the proposed plan, both input and output would be expressed in terms of "watts."

HARVARD
ENGINEERING JOURNAL

A QUARTERLY

DEVOTED TO THE INTERESTS OF ENGINEERING
IN HARVARD UNIVERSITY

THE OFFICIAL ORGAN OF THE ASSOCIATION OF HARVARD ENGINEERS

Published four times during the college year by the Board of Editors of the Harvard Engineering Journal in November, January, April and June.

Subscription Rates

Per year, in advance	**$1.00**
Single copies	**.35**

Advertising rates will be furnished on application to the Business Manager.
Address all communications to the heads of the respective departments:—

HARVARD ENGINEERING JOURNAL,
Room 218, Pierce Hall,
Cambridge, Mass.

Entered at the Post Office, Boston, Mass., as second-class mail matter, June 5, 1902

It is with profound regret that all Harvard men learn that Professor Ira Nelson Hollis must, by his acceptance of the presidency of Worcester Polytechnic Institute, soon terminate his years of faithful service to the University.

As Professor of Mechanical Engineering in the University since 1893, and Chairman of the Division of Engineering from

1893 to 1909, Professor Hollis has done much to bring engineering instruction at Harvard to its present high standing. His service to the University, however, has extended into many other fields. As Chairman of the Athletic Committee for many years, he was instrumental in raising the standard of athletics. It was he who directed the development of the permanent athletic grounds on Soldier's Field, and who brought the Stadium into existence. He took a leading part in the establishment of the Harvard Union in its present quarters, and is now Chairman of its Board of Trustees. The wide interest and activity that Professor Hollis has shown in Harvard affairs, and the intimate relations which he has maintained with all his students, have made him the close friend and adviser of an exceptionally large number of Harvard men.

The position to which Professor Hollis is called is one of great honor, responsibility, and opportunity. It is the sincere belief of the JOURNAL that his efforts in this new field will be crowned with the same success that has marked his work in Harvard University.

That the Navy Department should come to Harvard in connection with the layout of the work and equipment of its laboratories in its new course in Electrical Engineering for graduate officers at Annapolis, is a significant and gratifying indication of the position which the new Graduate School of Engineering has already attained. The increasing importance of electrical engineering to naval officers, not only in the operation of ships, but also in the Navy Yards of the country, makes such a step necessary, and it is a peculiarly happy circumstance that Harvard should be called upon to assume an initial responsibility in the carrying out of this important program.

President Lowell's annual report to the Corporation, published the latter part of February, contains a careful review of the changes in the Graduate School of Applied Science during the past year. This portion of the report, which should be of especial interest to Harvard engineers, is quoted in full below:—

"In the School of Applied Science important changes have

taken place during the year. A number of technical courses have been removed from the list open to undergraduates, carrying forward the design of placing the School on a graduate basis. At the same time the plan of instruction has been modified and made more intensive in method, so that a college graduate without technical preparation can be taught his Engineering, Mining, or Architecture in the shortest possible period. No doubt it will take time for the community to learn that a man who hopes to rise high in his profession gains in the end by a college education preceding his technical studies. Engineering ought to stand among the liberal professions which are enriched by a general education, and in fact the number of college men who enter engineering schools, though still small, is increasing year by year.

The organization of the School has also been altered. At the suggestion of the instructors, the departments have been formed into Schools of Engineering, of Mining and Metallurgy, of Architecture and so forth, each under a Council of instructors, the whole being grouped under a new and distinct Faculty of Applied Science. This has the double advantage of giving the Schools a more strictly professional tone under the government of a body devoted wholly to their interests, and of relieving the Faculty of Arts and Sciences of questions hardly germane to its regular work. The new organization nominally went into effect in September, 1912, but in fact the Faculty of Applied Science began its services in the year covered by this report, and its members are glad to work out their common problems in a meeting of this kind.

The Graduate Schools of Applied Science possess an admirable staff of professors, and already in some directions excellent equipment, but as yet few students, for the reputation in the profession which fills the classes is naturally of slow growth. It cannot be stimulated rapidly, and depends upon the achievements of the men that the institution has produced. These are the principal means of recruiting fresh students for any school, and years must always pass before their influence in the community is strongly felt."

The Harvard Engineering Society of New York has notified the School that they have raised a subscription for the sixteen secondary clocks to be installed in the recitation rooms, laboratories and library of Pierce Hall. Each clock is to have a twelve inch dial to bear the inscription: "Gift of the Harvard Engineering Society of New York, 1913." It is intended to have the clock system installed and in operation by next fall.

The Society wishes it announced that a cordial invitation to join its membership is extended to all men graduating from the Engineering School this year who plan to make their residence in or near New York. It is believed that the benefit will be a mutual one. On arriving in New York, men are urged to communicate with Mr. Charles Gilman, *Secretary,* 90 West Street.

These two notices are a pleasing demonstration of the excellent relations between the School and the Society, and of the very practical aid that the Society renders to the School and its graduates. Such relations cannot fail to benefit all concerned. They are the direct expression of the good feeling and co-operation existing among Harvard engineers, which must react most advantageously to the prestige of the School.

Designs for engineering construction in regions such as New England rarely take into consideration resistance to possible earthquake shock. The following excerpts in regard to this matter are taken from the recently published fourth annual report of the Harvard Seismographic Station for the year 1911-12, and should be of interest to engineers and architects.

" . . . . The fact abundantly illustrated in the San Francisco earthquake of 1906 that a fault zone of geologically recent date may at any time undergo renewed motion giving rise to an earthquake makes it desirable in the interests of humanity to locate on maps such lines of danger and point out their existence for the avoidance of unnecessary risks such as arise from ignorance in the choice of location of important public works or private buildings. . . . The importance of engineers and architects taking into account the liability of earthquake shock strong enough to damage buildings in this district (Massachusetts) is amply shown by the history of earthquakes at Plymouth,

Newburyport, and Boston in the 17th and 18th centuries. There can be little doubt that the recurrence of such shocks as were felt in Boston in 1755 would produce much damage. . . . While the Atlantic coast of the continent is relatively immune from earthquakes, the case of Charleston in 1886 enforces attention upon the necessity of recognizing the risk of destructive shocks upon this coast at long intervals perhaps of a few centuries only. Sane precaution demands the avoidance of the mistake made at San Francisco of placing a public reservoir upon a fault zone of recent movement, and of the folly of cheap mortar and rubble masonry which together were factors of first importance in the loss of life and property in Charleston in 1886, and in Messina in 1908. We may not be able to avoid building our houses and public edifices upon ground liable to destructive shocks, but we have abundant information as to how these structures should be built in order to reduce the risks of demolition to a minimum."

At the request of the JOURNAL, the President of the Harvard Engineering Society has written the following comment on the object of the reorganization of the Society two years ago, and how that object is being attained in actual practice. The Society on its present basis is undoubtedly a success, but its usefulness would be greatly increased if the meetings were better attended. Those who have its welfare at heart desire that all members of the School of Engineering (including seniors taking courses in the School) will realize the mutual benefit to themselves and to the Society that will result from their regular attendance at the meetings.

The work of the Engineering Society has been going on quietly but regularly, throughout the year. Papers have been presented twice a month, and nearly always by students. The audiences have been small and limited to a faithful few who have given very constant attendance. Although this small attendance is disappointing, yet it is not surprising, for the announcement of a paper by a student does not attract great attention. Very few students have had the necessary experience to qualify

them to deliver a lecture which is of general interest to men in all branches of engineering. But the lack of full attendance, nevertheless, is to be regretted, because it tends to limit the usefulness of the Society as a training school in exposition and in discussion. It tends to dampen the spirit of the meetings, and to discourage the efforts of the speakers.

This being the case, is the Society justified in its present existence? Is it fulfilling the aims which were held in view at the time of its reorganization two years ago? Should the old form of society be reverted to, or should the Society be abandoned? It is the opinion of the President that the Society's existence is justified in spite of the lack of spirit among the members, and that it is accomplishing its purpose infinitely better under its present form than it did under its old form. What, then, is its present purpose?

The purpose of the change in the Society from a large, inactive undergraduate membership to a small, active, graduate one, was to arrange it so that members might do nearly all of the speaking. The engineering profession is generally believed to have suffered from a lack of popular recognition. The business man can advertize in the papers; the lawyer can go into politics; the clergyman can appear in print by delivering a startling sermon; the physician, meeting his clients in person, and often holding their lives in his hands, can build up a valuable reputation. How can the engineer become known?

First, of course, he must deserve to become known. He must do his work thoroughly and efficiently. But many engineers have done this and have not succeeded, because their work has attracted no attention, and they have lacked the push to establish a reputation where it would count. There is one way of becoming known which is always open to the engineer. He must write or speak. He must write for the scientific magazines, or he must speak, when occasion offers, before men who will be interested in the results of his investigations or in his acquired experience.

The students in the Engineering School have acquired little experience, and their investigations of theoretical or practical problems have been very limited. But they can practice the

form, though the substance be somewhat lacking. In a word, our Society, whether large or small, is the natural training school in which to gain the fluency and confidence in speaking which is necessary to the engineer in dealing with the public. The most encouraging element of the present organization is the fact that a general willingness has been shown among the men to accept the burden of giving the papers. They have appreciated the opportunity to address the Society, but they have utterly neglected the opportunity, equally important, of listening, criticizing, and discussing. This partial acceptance of opportunity has been in itself the justification of the change which was made, and has firmly established the present form of the Society. If a high standard of discussion and attendance is attained, a career of great usefulness will be opened in the future. K. R. GARLAND.

"The contract for the construction of the Widener Memorial Library has been awarded to a Philadelphia firm in accordance with plans and specifications prepared by Mr. Horace Trumbauer, the architect. As was expected, the work of demolition of Gore Hall did not take more than five weeks. All the materials other than the stone blocks which will be used in the foundations of the new structure are being carted away. The contract for the new library includes the excavation, concrete foundations, cut-stone and brick work, fire and damp proofing, structural metal and miscellaneous iron work, carpentry, plaster, decorative marble work, interior wood finish, or any of the library furnishings except the steel book stacks. The amount of the contract was not made public, but is understood to be in the neighborhood of $2,000,000."—*Harvard Graduates' Magazine* for March.

Roscoe E. Scott, '07, of the General Electric Company of Cleveland, Ohio, who has an article on the incandescent lamp industry in this number of the JOURNAL, is the author of an article which appeared in a recent issue of the *Scientific American* on the results of the experiments of the French Physicist, Dussaud, in his "Cold Light Laboratory." The invention of

the "cold light" takes a big step forward in the art of electric illumination. Not only is the voltage of the light more than doubled by means of Dussaud's apparatus, but at the same time the electrical energy consumed is less than one-fifth of that required for any other illuminating device using incandescent lamps. It is bound to be of extremely practical importance to the future moving-picture machine, inasmuch as it never becomes heated and its adaptability to lenses of short focus will allow the present dimensions of the positives (8 x 10 cm.) to be reduced to 19 x 24 millimeters. Other uses to which it may advantageously be put are light-house beacons, endoscopy, flash-light photography, and beautiful indirect-lighting effects for libraries, conservatories, and drawing-rooms.

The long desultory agitation for a new gymnasium to replace Hemenway has recently taken definite shape, and there is now every prospect that sufficient funds for the purpose will soon be available. Some of the graduates have promised to donate a large amount of the necessary sum if it were shown that the undergraduates are also lending their active support to the plan. The Executive Committee of the Student Council has therefore appointed a committee to supervise the collection of subscriptions from undergraduates, and the resulting amount pledged to the gymnasium fund has been so gratifying that the new building is now practically assured.

It was voted at the meeting of January 13, 1913, that the President and Fellows of Harvard College desired to express their gratitude to Miss Harriet Otis Cruft, for her gift of fifty thousand dollars for the new high tension electrical laboratory building to be called the Cruft Memorial Building.

The editors of the JOURNAL are authorized to announce that members of the editorial staff are hereafter to be chosen from a list of candidates approved for their standing in engineering studies, and for their general fitness, by the Council of the School of Engineering; thus making election to the board of the JOURNAL a mark of distinction.

ASSOCIATION OF HARVARD ENGINEERS

ADDENDA TO THE MEMBERSHIP LIST OF MAY, 1912

(*See also* JOURNAL *for January, 1913*)

Jones, Guy Lincoln, A.B. 1903, United States Gypsum Co., 205 W. Monroe St., Chicago, Ill. (1913).

Nichols, Charles Eliot, A.B. 1907, Constructing Engineer with Stone & Webster, 147 Milk St., Boston, Mass. (L. 1913).

Richardson, Clifford, A.B. 1877, Consulting Engineer, Portland Cement, Highways, 30 Church St., New York City.

Rice, Clifton Littlewood, A.B. 1912, 202 Auburn St., Cambridge, Mass.

Sayre, Robert Harold, A.B. 1908, Mining Engineer, Central City, Colo.

Shaw, Arthur Wyman, 1903-6 (1907), 1272 Clay Ave., Bronx, N. Y.

HARVARD ENGINEERING SOCIETY

Since the last issue of the JOURNAL, four meetings of the Society have been held, two of which were addressed by outside speakers.

On January 10, Mr. S. Rosenzweig, of the Erie City Iron Works, gave an illustrated talk on "Superheat and the Application of the Lentz System to Different Types of Prime Movers." The speaker described in some detail the adaptation of the poppet type of valve to the steam engine, and the many advantages over the "old style" slide, piston, and Corliss valves. A very important claim was that this made possible the use of much higher superheat, resulting in an improved efficiency. The lantern slides showed various details, installations, and applications of this and other types of engines. The discussion after the lecture was animated, and attention was drawn to several interesting aspects of the situation.

This meeting was followed by another on January 24, at which Mr. R. B. Pendergast spoke on "The Work of the U. S. Reclamation Service." The development of irrigation engineering was outlined, and the purpose of the Reclamation Service

explained. Several western projects were described and the numerous difficulties encountered in the work were pointed out. The various construction details were very effectively shown by a large number of lantern slides. The talk covered the method of obtaining water supply, construction of dams, incidental development of water power, distribution of water for irrigation, and the various effects of climate, topography, and rainfall upon the problem. Much of the information was gained from personal experience, the speaker having been employed as assistant engineer on some of the government work.

The next meeting of the Society was held on Friday evening, February 14. A paper was presented by Mr. E. L. Robinson on "The Elementary Principles of Aerodynamics and their Application in the Design of an Aeroplane." The fundamental aspects of the subject were explained showing the many difficulties encountered in the attempt to reduce the science to a mathematical basis. Most of the present day design depends upon the use of coefficients determined by experiment. A large number of curves and diagrams were shown bringing out the behavior of various types of planes and wings, and the ingenious graphical methods which may be used in the design of an aeroplane. The essentials of a practical design were described, and each step explained, together with the limitations involved. The speaker was frequently interrupted by questions, and a general interest and appreciation was manifest.

A special meeting was held in Room 110, Pierce Hall, on the evening of February 24. Dr. Milton W. Franklin, of the Engineering Staff of the General Electric Company, gave a lecture on "Ozone, Its Production and Practical Application." The meeting was open to the public and a large audience resulted. Dr. Franklin explained the theory of ozone production under the influence of the potential discharge between suitable electrodes. A commercial ozonator was exhibited and operated. He then described in some detail the uses to which ozone has been applied, such as air and water purification. It was claimed that very good results could be obtained in manufacturing plants for destroying noxious odors which no amount of fresh air

could remove. The practical use of ozone is of very recent date and its exact value is not yet completely understood. This latter fact drew considerable attention to the lecture.

WIRELESS SOCIETIES

HARVARD WIRELESS CLUB

The Harvard Wireless Society has been holding its regular meetings. Various members of the Society have given short lectures on the topic for the evening. These topics have been arranged to form a systematic course on wireless telegraphy, as previously announced.

At one of the meetings, Mr. A. C. Zwicker, of the Clapp-Eastham Company, gave an interesting talk on the rotary spark gap, discussing both the theory and the mechanical construction of the gap.

The club has recently been presented with a Ferron detector, and two variable condensers, from the Clapp-Eastham Company. This completes the receiving outfit of the Club. All the instruments are of high quality, and give very satisfactory results.

WM. H. CAPEN, *Manager.*

NEW ENGLAND WIRELESS SOCIETY

The third meeting this season of the New England Wireless Society was held January 4 in the Jefferson Physical Laboratory Professor G. W. Pierce, the speaker of the evening, confined his remarks to the phenomena connected with doubly periodic and induced oscillations in coupled receiving circuits, describing various experiments which have been conducted at the laboratory using the Chaffee gap and other means of excitation. After Dr. Pierce's instructive remarks, which were enlivened by several lecture-table demonstrations, the meeting adjourned to the wireless laboratory where the various forms of experimental apparatus there were inspected, among them being the Braun tube in action as an oscillograph recording

oscillations such as were the subject of the discourse. The meeting later reconvened in the lecture-hall for discussion and formal business.

The fourth meeting was held in Walker Building, Technology, February 1. Professor R. A. Fessenden was the guest this evening. He favored the Society with an interesting and instructive talk on high-frequency oscillations and apparatus as applied to radio-telegraphy and telephony.

The fifth meeting of this season was held in the Jefferson Physical Laboratory, March 1. Doctor E. L. Chaffee was the speaker, his subject being the Chaffee gap and its operation, especially as applied to radio-telegraphy and telephony. He described first the various modern spark and arc systems of producing oscillations, mentioning the peculiar characteristics of each. Touching on the way in which he came to design it, he next explained the construction, operation, and theory of the Chaffee gap, and ended with an account of the numerous ways it can be utilized in experiments and systems of radio-communication. These concluding remarks were enhanced by a pretty and somewhat spectacular demonstration in miniature of the oscillation of an antenna.

Professor A. E. Kennelly is scheduled to speak April 5 on atmospheric and meteorological conditions as affecting radio-communication. Following him, one or perhaps two speakers not yet announced, will take up the remaining meetings of this season.

GRADUATE NOTES

(On account of the many inquiries as to the whereabouts of the graduates of the department, it is hoped that the Graduate Secretary will be notified of changes of address or occupation, etc. Such notes will appear promptly under this heading.)

HENRY M. HOWE, '69, has been elected an honorary member of the Cleveland Institution of Engineers and of the Russian Metallurgical Society. He was also elected president of the Sixth Congress of the International Association for Testing Materials and a life member of the Council, a distinction paid to only two men since it was organized.

Charles Moore, '78, has been re-elected chairman of the District City Plan and Improvement Commission which has charge of the preparation of a plan of Detroit and surrounding territory.

R. Clipston Sturgis, '81, of Boston, was elected vice-president of the American Institute of Architects at its annual convention held in Washington in December.

Frederic A. Delano, '85, of Chicago, president of the Wabash Railroad, was appointed by President Taft a member of the Commission on Industrial Relations, to study industrial conditions in the United States and report to Congress thereon within three years after August 23, 1912.

Lieut.-Col. William V. Judson, '86, A.M. (hon.) 1911, has been appointed by President Taft assistant to the engineer-in-chief of the Panama Canal. For the last four years Col. Judson has been engineer commissioner of the District of Columbia.

Caleb M. Saville, '89, Chief Engineer, Board of Water Commissioners, Hartford, Conn., was elected vice-president of the New England Water Works Association at the annual meeting on January 8.

Philip L. Spalding, '92, who has been general manager and second vice-president of the Bell Telephone Co. at Philadelphia, has been elected president of the New England Telphone and Telegraph Company.

W. M. Booth, '93, chemist and engineer, of the Booth Apparatus Co., should be addressed at the Dillaye Bldg., Syracuse, N.Y. His specialty is "questions relating to water supply" both for drinking and power purposes.

Robert D. Farqhuar, '93, is one of the nine members of the architectural commission for the San Francisco Exposition in 1915, and has designed the Hall of Festivals. His address is Van Nuys Building, Los Angeles, California.

Alfred H. Brooks, '94, geologist in charge of the Division of Alaskan Mineral Resources, U. S. Geological Survey, was vice-chairman of the Alaska Railroad Commission which was ap-

pointed late last summer by President Taft. An extensive report on the findings of the Commission was submitted to Congress on February 6.

E. S. DODGE, '95, architect, has opened offices at 39 W. 38th St., New York, and 15 Exchange St., Boston.

A. W. K. BILLINGS, '95, is now Managing Director of the Ebro Irrigation & Power Company, Barcelona, Spain.

EUGENE DU PONT, '97, was married at Wilmington, Del., on January 25, to Miss Ethel Pyle.

C. S. DOW, '97, is now living at 354 Wolcott St., Auburndale, Mass.

FREDERICK E. OLMSTED, Gr. '97-'98, has withdrawn from the firm of Fisher, Bryant and Olmsted, consulting engineers, of 141 Milk St., Boston. The business has been incorporated under the name of Fisher and Bryant, Inc. (Professor Richard T. Fisher, '98, and Edward S. Bryant, '00). Mr. Olmsted will maintain close professional relations with the new corporation. His address is 21 Lime St., Boston.

TYRRELL B. SHERTZER, '00, is at present Resident Engineer for the W. J. Rainey Coke Co., and is building a dam at Allison, Penn. His permanent address is 85 W. Preston St., Baltimore, Md. His temporary address is Care W. J. Rainey, Uniontown, Penn.

E. T. P. GRAHAM, '00, is architect for the new Boston City Hall Annex and the Forsyth Dental Infirmary.

C. M. BROWN, '00, is in the Great Western Power Co., in Napa, Cal. Home address: 637 South Randolph St.

W. H. ARMSTRONG, '00, after two years' work, has finished his survey and map of Porto Rico. The report consists of 25,000 words and includes 540 photographs. It has been highly commended by the War Department.

G. E. CLEMENT, '00, is in the U. S. Forestry Service; his headquarters are at Room 722, 6 Beacon St., Boston.

MURPHY & DANA, architects, of New York, of which firm Richard H. Dana, Jr., '01, is a member, won the prize offered for the best design for the school buildings of the Loomis Institute in Windsor, Ct.

CHARLES S. SHAUGHNESSY, '01, is in civil engineering at Cold Spring-on-Hudson, N. Y.

HERMAN F. TUCKER, '01, has opened an office at 432 Pioneer Building, Seattle, Washington, as consulting engineer, specializing in steel and reinforced concrete. For four years he was Designing Engineer on the plans for the Panama Canal lock masonry and valves, and during the past year he has been resident engineer on the construction of the fourteen buildings for the Peter Bent Brigham Hospital in Boston.

HARRY C. DUDLEY, '02, mining engineer, is at 807 Lonsdale Bldg., Duluth, Minn.

WILLIAM C. CLARK, '03, is in Panama with the McClintic-Marshall Construction Company, which has the contract to build the gates in the Isthmian Canal Locks at Gatun. He is assistant superintendent of erection on the Miraflores gates.

FRANK H. LEMONT, '03, is general manager of S. V. Estes, Inc., efficiency engineers, 1834 McCormick Bldg., Chicago.

GUY L. JONES, '03, who was in Mexico during the recent revolution, has returned home and is now with the United States Gypsum Company, 205 Monroe St., Chicago.

J. H. HALL, '03, 165 Broadway, New York City, is a consulting metallurgical engineer.

CHESTER W. WASHBURN, s. '05-'06, Geologist and Mining Engineer, is associated with Bailey Willis in a study of the mineral and other resources of territory tributary to the new transcontinental Railroad from San Antonio Oesti Argentina, to Valdivia, Chili. Mr. C. F. Eberly, formerly instructor at the Engineering Camp, is engaged on the same line making topographic maps for the preliminary location of the line.

HOWARD E. SIMPSON, A.M. '05, is Assistant Professor of Geology at the University of North Dakota and Assistant State Geologist.

H. L. LINCOLN, '06, former Editor-in-Chief of the JOURNAL, is instructor for the training of central station service salesmen in the Chicago Central Station Institute. The institute furnishes commercial men for all concerns interested in the sale of electrical energy.

John D. Shaw, '06, is practising Landscape Architecture at 232 Security Bldg., Los Angeles, California.

E. Raymond Shepard, A.M. '06, is Assistant Professor of Electrical Engineering at the Oregon Agricultural College. His address is Corvallis, Oregon.

Harold Vincent Skene, '06, is practising architecture in Bedford, Mass.

Frederic H. Swift, '06, is a general contractor with offices at 85 Devonshire Street, Boston.

Howard M. Turner, '06, engineer of the Turners Falls Company, Turners Falls, Mass., was married to Miss Helen Choate Eustis in Cambridge, on February 8.

A. R. Bacon, '06, is chief draughtsman in the signal department of the Boston and Maine R. R.; business address, Room 211, Old Fitchburg Depot, Boston: home address, Fletcher Road, Bedford.

P. L. Beckwith, '06, is Division Traffic Engineer of the N. Y. Telephone Company, in charge of the Manhattan-Bronx Division; business address, 15 Dey St., New York City: home address, 472 Benedict Ave., Woodhaven, N. Y.

J. Lissner, '06, is working for the municipal engineer of Burnaby, B. C. Address: Municipal Hall, Burnaby, B. C., Canada.

C. Wallace, '06, is in the engineering department of the American Tel. & Tel. Co. Business address: 15 Dey St., New York City; permanent address, 26 Leighton Ave., Clinton, New York.

Vilhjalmur Stefanson, G.S. '06, who has recently returned from an exploring expedition of five years in the Arctic regions, spoke before the December meeting of the New York City Harvard Club, on "The Eskimos of Coronation Gulf." Dr. Stefanson was the discoverer of a group of Eskimos with European-like characteristics. He is planning a further Arctic expedition in the spring of 1913.

KNOWER MILLS, '07, of the U. S. Forest Service, has been transferred from Nevada City to the Feather River Experiment Station, Quincy, Cal.

R. K. STRONG, '07, is teaching at the Manual Training High School in Louisville, Ky.

WALTER M. BIRD, '08, who has been for some time with the Stone & Webster Management Association, has been transferred from the Houston Electric Company to the Jacksonville Traction Company, Jacksonville, Fla.

O. W. HARTWELL, '08, assistant engineer in the Water Resources Branch of the U. S. Geological Survey, is located at Albany, N. Y. He is principal assistant to the District Engineer, and has charge of office computations and routine field work.

EDWARD L. LINCOLN, '08, is engineer for the standard time department of S. D. Warren & Company, Cumberland Mills, Me. His address is 124 Glenwood Ave., Woodfords, Me.

GEORGE A. MCKAY, '08, who has been until recently employed by the Canadian Government as engineer on the Quebec Bridge, is now with the American Felt Company, 60 Federal Street, Boston. His home address is City Mills, Mass.

FREDERIC W. SWAIN, '08, is manager of the Columbus Department of the Milford Iron Foundry. His address is 96 School St., Milford, Mass.

CHESTER CONRAD RAUSCH, '09, whose home address is Bedford, N. H., is with the Stone & Webster Corporation, employed as resident engineer on various construction works.

RALPH H. ARONSON, '10, formerly with the Roebling Construction Company, is with Willett, Sears & Company, 60 Federal St., Boston.

WARREN ORDWAY, '10, is with the Green Fuel Economizer Company, Boston.

WILLIAM K. PAGE, '10, is in the research laboratory of the Chile Exploration Company at Maurer, N. J. His address is 149 Kearney Ave., Perth Amboy, N. J.

F. Fish, Jr., '10, is with the Fuller Construction Company, New York.

Stuart D. Coward, '11, has entered into partnership with his father at Holyoke, Mass., under the firm name of Coward and Coward. They will conduct an electrical engineering and electrical repair business. His address is 94 Sycamore St., Holyoke, Mass.

Calvin D. Crawford, '11, is in the mining department of the Canadian Copper Company, Copper Cliff, Ontario.

Ray P. Dunning, '11, has been transferred from Perth Amboy, N. J., to the Monterrey plant of the American Smelting and Refining Company. His address is care of the company, Nuevo Leon, Monterrey, Mexico.

Joseph B. F. Gamage, '11, is with the Stone & Webster Engineering Corporation: his headquarters now are at 36 Brook St., Pawtucket, R. I.

H. A. Mundo, '11, is in the engineering and inspection department of the John C. Paige Insurance Company.

William H. Myer, '11, is in the test department of the General Electric Company. His address is 127 Plunkett St., Pittsfield, Mass.

Philip C. Nash, '11, M.C.E. '12, is a civil engineer with the Boston Transit Commission.

F. P. Donovan, '11, is an engineer for the Hugh Nawn Contracting Company.

R. K. Nash, '11, is mechanical engineer and inspector for the Massachusetts Employees' Insurance Association, 84 State St., Boston.

F. B. Byerly, '11, is with the Haughton Traction Company, one of the subsidiary companies of Stone & Webster.

R. C. Staebner, '11, is in the U. S. Forestry Service, Washington, D. C.

D. B. Adams, '12, is with the N. E. Cement and Stone Company, 74 Broad St., Boston.

R. T. Alger, '12, is studying at M. I. T.

G. H. BALCH, '12, is with Stone & Webster, 147 Milk St., Boston.

W. H. BIXBY, '12, is instructor at the General Electric Engineering School, West Lynn, Mass.

J. E. BOIT, '12, is with the Holbrook, Cabot and Rollins, corporation contractors, St. Louis, Mo.

F. W. CANDEE, '12, is an electrical engineer at Wallace, Ida.

H. W. CLAUSEN, '12, is a civil engineer with the U. S. R. S. at Batt, Mont.

N. DAVENPORT, '12, is surveying with the N. Y., N. H. & H. R. R.

M. S. DOW, '12, is transitman with a Turner's Falls company.

F. W. HILL, '12, is with the Hill-Ray Engineering Company, 110 State St., Boston.

P. K. HOUSTON, '12, is with the Western Electric Co. at Hawthorne, Ill.

A. C. MURRAY, '12, is practising civil engineering at Fall River.

W. J. POWER, JR., '12, is a civil engineer with the Boston Transit Commission, field office, Charlesgate East and Newbury St., Boston.

C. M. RAMSAY, '12, is construction engineer with Barrows-Stewart Company, general contractors, Westfield.

I. E. REED, '12, is with the General Electric Company, testing department, Lynn.

L. D. SMITH, '12, is efficiency engineer for the Wisconsin Steel Company, Benhan, Ky.

L. C. TORREY, '12, is assistant engineer, 1st division, Atlantic Coast Line R. R., at Roday Mount, N. C.

L. W. WEED, 1 GS., is carrying on an experimental investigation of the shearing strength of joints between old and new concrete. He is also making some special investigations regarding the tensile strength of cement.

M. E. Wolfard, 4 GS., is doing research work in the use of crude oils in internal combustion engines. A note on the results of his experiments will appear in the June number of the Journal.

PERSONAL NOTES

Professor Ira N. Hollis, h. '99, has accepted the invitation of the Worcester Polytechnic Institute to become president of that institution, the appointment to take effect July 1 of the present year.

At the annual meeting of the American Society of Civil Engineers held in New York, George F. Swain, Gordon McKay Professor of Civil Engineering, was elected President for the year 1913. Of the forty-two presidents of the Society up to the time of his election, there have been four Harvard men, as follows: Thomas C. Clarke, s. '51-'52; Benjamin M. Harrod, '56; George S. Morison, '63; Frederick P. Stearns, h. '05. The society is one of the oldest engineering organizations in the country, and has a membership in all grades of about 6,800.

Professor H. E. Clifford is spending the first two weeks in each month during the present half-year, at the Naval Academy at Annapolis, to consult in regard to the layout of a course of study in electrical engineering for graduate officers of the Navy. He will also, while there, select and in part install the equipment for the new laboratories of electrical engineering, and will give certain work of instruction to naval officers. This is the result of an invitation of the Navy Department to Harvard University to co-operate in the establishment of a course of instruction in electrical engineering, with the idea of training a group of specialists among the officers of the Navy.

Mr. C. F. Warrick, Assistant in Electrical Engineering, resigned on February 1 to accept an advantageous opening with the Fairbanks Company. His position in the Department has been filled by the appointment of Mr. C. B. Hoffman, a graduate of Cornell University, '12, who comes for the remainder of the academic year.

Professor C. A. Adams is conducting some of the work of Professor Jackson, of Technology, who is in England acting as expert for the English government.

Professor Albert Sauveur has been appointed a representative of the American Institute of Mining Engineers on the "John Fritz Medal Board of Award," to serve for a period of four years.

Mr. L. A. Doggett is taking Mr. C. L. Dawes' place at the Franklin Union during the latter's absence at Annapolis.

Dr. E. L. Chaffee addressed the New England Wireless Society on "Wireless Telephony," March 1, in Jefferson Physical Laboratory.

Professor A. E. Kennelly is a member of the Board of Syndics in charge of the new University Press. The Board decides upon the books to be published.

Professor H. E. Clifford addressed the Business Men's League of Cohasset on February 20, on the subject of "Rates for Electric Service."

Professor E. V. Huntington lectured on "An Improved Railroad Transition Curve" before the Harvard Mathematical Club, March 12.

Professor A. Sauveur lectured on "Metallography" before the Franklin Institute, Philadelphia, on February 13.

Professor H. E. Clifford has been elected to the Board of Managers of the New England Branch of the Illuminating Engineering Society. He is also Chairman of the Nominating Committee. The fact that the subject of Illuminating Engineering at present receives no adequate treatment in most of the colleges and technical schools, has led the Illuminating Engineering Society to form a committee of ten members whose function shall be the formulation of a course of study in illuminating engineering and an investigation of the conditions for introducing it in the educational institutions of the country.

Professor G. C. Whipple has been elected an honorary member of the Boston Bacteriological Club.

Professor E. V. Huntington gave three lectures on the Elementary Theory of the Algebra of Imaginary Quantities on February 28, March 3, and March 5. These lectures, while presenting the subject solely from the point of view of the mathematician, were intended to be of special service to students of electrical engineering.

Professor A. E. Kennelly presided at the Midwinter Convention of the American Institute of Electrical Engineers, in New York, February 26-28, the convention being held under the auspices of the A. I. E. E. Standards Committee, of which he is chairman.

Professor H. J. Hughes addressed the Cambridge Club on January 20 on "The Development of the Cambridge Water Supply."

Professor H. E. Clifford has been engaged by the Direct Turbine Company to supervise the initial tests of their new design of homo-polar generator. This generator involves a number of new and interesting features and the outcome of the tests is awaited with considerable interest by the engineering fraternity. If the design proves successful, it will mean a noteworthy advance in the direct-current turbo-generator field.

Professor A. E. Kennelly gave a lecture to the Pittsfield Section of the American Institute of Electrical Engineers, Thursday, March 13, on "Wireless Telegraphy and Telephony."

Professor L. J. Johnson exhibited some photographs of reinforced concrete T-beams before the American Academy of Arts and Sciences on February 20, showing some novel and significant results of his recent experiments.

Professor A. E. Kennelly will be the speaker of the evening at the meeting of the New England Wireless Society on April 5, in Pierce 110. All members of the University who are interested in wireless telegraphy are cordially invited to be present.

Professor G. F. Swain has recently given the following addresses:—January 14, before the American Institute of Consulting Engineering on "Engineering Education"; January 17,

before the Civil Engineering Graduates of the Massachusetts Institute of Technology at the New York meeting; on February 18, before the American Association of Landscape Architects at Boston; on February 28, before the Master Builder's Association of Boston, on the "Subways of Boston."

Professor W. M. Davis was awarded the Culver Gold Medal of the Geographic Society of Chicago at the annual dinner of the Society on February 19.

Professor J. S. Pray has been elected Vice President, and Professor H. V. Hubbard has been elected Treasurer, of the American Society of Landscape Architects.

Professor I. N. Hollis received the degree of S.D. from the University of Pittsburgh during the last year.

Professor W. C. Sabine presented a paper entitled, "The Reaction of the Room on the Source of Sound" before a meeting of the American Physical Society at Cleveland on January 1.

Professor E. V. Huntington presented a paper entitled "A Set of Independent Postulates for 'Betweenness'," at the Cleveland meeting of the American Mathematical Society in January. The paper was read by title.

Professor E. D. Peters delivered a lecture before the Harvard Mining Club in the Harvard Union, January 14, on "Organization and Dangers of Mining Companies."

Some of the students in the Electrical Engineering Department, who are studying electric railway engineering, are at present working on the problem of the electrification of the Newton Circuit of the Boston & Albany R. R., carrying on the study under the direction of Professor Clifford. The work involves a study of population and the determination of the probable traffic, the investigation of the system of traction to be adopted, and the layout of the power station for supplying the current. It is also probable that some study will be made of gasoline motor cars.

Recent Publications by the Staff

"Shearing Strength of Construction Joints in Stems of Reinforced Concrete T-Beams as shown by Tests." L. J. Johnson and J. R. Nichols. *Proc. Am. Soc. Civil Engineers.* pp. 201-214. February, 1913.

"The Heat Balance in Steam Boilers." L. S. Marks. *Power.* January 14, 1913.

"Discussion on the 'Vibration of Telephone Diaphrams'." A. E. Kennelly and G. W. Pierce. *Proc. Am. Inst. Electrical Engineers.* Dec. 1912.

"The Impedance of Telephone Receivers as Affected by the Motion of their Diaphrams." A. E. Kennelly and G. W. Pierce. *Proc. Am. Academy of Arts and Sciences,* 48: 509-527.

"The Water Supply of Cambridge." *Expert Reports upon the Development of the Water Supply of Cambridge, Mass.* pp. 43-53. H. J. Hughes. Published by the City. 1912.

"Disturbances of Potential and Current Produced in an Active Conducting Network by the Application of a Peak Load." A. E. Kennelly. *Electrical World.* 60: 1373-1376. December 28, 1912.

"Progress of Electrical Science in 1912." A. E. Kennelly. *Electrical World.* 61: 3, 4. January 4, 1913.

"Biographical Notice of Floris Osmond." Albert Sauveur. *Bulletin of the American Inst. Mining Engineers.* 43: 309-318. February, 1913.

"Notes on Cast Iron." Albert Sauveur. *Bulletin of the American Inst. Mining Engineers.* March, 1913.

"Synchronous Motors and Converters." André Blondel. Translated by C. O. Mailloux; with two chapters contributed by Professor C A. Adams. New York. 1913.

Appointments and Resignations

Mr. C. B. Hoffman has been appointed Assistant in Electrical Engineering from February 1, 1913, for the remainder of the current year in place of Mr. C. F. Warrick, who has resigned.

Mr. H. G. Crane has been appointed Instructor in Electrical Engineering from March 1, 1913.

Mr. Chester L. Dawes is on leave of absence to serve as Instructor in Electrical Engineering at the U. S. Naval Academy at Annapolis during the second half-year.

The Harvard Engineering Camp

The summer engineering camp at Squam Lake, N. H., will open this year on Saturday, June 21, and will close, with the exception of a few graduate courses, on Saturday, September 6. The camp is situated on the eastern shore of the lake and comprises 700 acres, with living accommodations, and drawing and drafting rooms for several hundred students. Men may go to the camp on the 9 o'clock train from the North Station to Ashland and thence by boat the remainder of the way.

Admission to the camp is open to men qualified as follows: students registered in any department of the University; students in other educational institutions; and students with or without college affiliations, who register in the Summer School.

The fee for these courses has been changed to $10 a week instead of $11, as in the past, this including board, lodging in a tent, laboratory fees, and instruction. For the purpose of registration special cards have been provided, which can be obtained at Pierce Hall 114A.

Courses for Undergraduates

The following courses for undergraduates will be given at the camp:

Engineering Sciences 4a.—Plane and topographic surveying, a half course for five weeks beginning June 21.

Engineering Sciences 4d.—Railroad surveying, a whole course for six weeks following 4a.

Course 4a and the first three weeks of course 4d, if both are taken in the same summer, may be counted as a whole course. This regulation went into effect last year for the first time.

Graduate Courses

In addition to the undergraduate courses, certain courses in the School of Engineering will be given at the camp.

The schedule of work in the School of Engineering is so organized as to utilize the entire calendar year for work. By this plan the professional courses for graduates are distributed over four sessions, namely—the First Summer, the First Year, the Second Summer, and the Second Year.

The following graduate courses are given in the summer of 1913:

Engineering 4K.—Plane and topographic surveying, for four weeks beginning June 21.

Engineering 4L.—Railroad surveying, for four weeks beginning July 19.

Engineering 2K.—Elementary mechanics and drawing for five weeks beginning August 16.

Engineering 4M.—Road engineering, for two and one-half weeks beginning June 21.

Engineering 4N.—Railroad engineering, for three and one-half weeks beginning July 10.

Engineering 7L.—Mechanics of structures (including reinforced concrete), for five weeks beginning August 4.

Engineering C9L.—Limnology—physics and biology of lakes and reservoirs, for ten afternoons beginning August 18.

Engineering 16M.—Direct and alternating currents, and direct-current machinery, beginning June 21, first five weeks at camp, the last six weeks in Cambridge.

Each course requires, during the period assigned to it, the concentrated use of all the working day; and, with the exception that Course C9L and Course 7L may be taken together, a student may take only one course at a time. The daily schedule at the camp is as follows: rising hour, 6 o'clock; breakfast, 6.25 o'clock; working hours, between 7 and 12 o'clock, and between 12.45 and 4 o'clock. On Saturday, however, the working hours are between 7 and 12 o'clock.

NOTICES

Sixteen members of the class in Sanitary Engineering are receiving the Typhoid Prophylactic Treatment which has proved so successful in the British and U. S. Armies. The partial protection secured by the inoculation is effective for at least a year and a half, and probably longer.

An electric furnace for the calibration of pyrometers and for the determination of the fusing temperatures of refractives, and a second venturi meter for hydraulic investigations have been added recently to the engineering laboratory.

A six cubic foot Cube Concrete Mixer, motor driven, has also been installed and put in operation in the laboratory.

Engineering 7K, *Foundations, Masonry, and Fireproofing,* which was advertised to be given in the summer has been replaced by Course 4N—*Railroad Engineering.* 7K will be given during the first half-year at Cambridge.

A new course, Physics 4*c*, *Radiotelegraphy,* has been added for the second half year. This is an advanced course given by Assistant Professor G. W. Pierce, and is open to students who have taken Physics 4*b*, or Engineering E17K.

The following publications have been issued recently:

The Announcement of the Summer Course in Municipal Sanitation for 1913.

The Announcement of the Courses in Sanitary Engineering for 1913-14.

The announcement of the summer session of the School of Engineering.

The announcement of the Engineering Camp for the Summer of 1913.

The following engineering courses will be given in Cambridge during the summer of 1913:

Shop-work courses: 10a and 10b begin June 23—4 weeks.

Shop-work courses 2: 10c and 10e begin July 21—4 weeks.

Engineering C9M (*Sanitary Engineering Laboratory*) *begins* September 8—2 weeks.

Engineering 16M (*Direct and Alternating Currents and Direct Current Machinery*). Last six weeks in Cambridge; the work at Cambridge begins July 28.

Municipal Sanitation and Hygiene—Professor Whipple will give a 6 weeks' course beginning June 30.

The fees in the shopwork courses for students in the School of Engineering, and for undergraduates in Harvard College who have paid a full year's tuition, will be as follows: for the courses 10a, 10b, 10c, and 10e, a shop work fee of $10.50 for each course—for other students, the fee will be $16.00 for each course. All fees must be paid in advance.

The D has been eliminated from the marking system of the Graduate Schools of Applied Science. Thus a man will either fail to pass a course, or will get at least a satisfactory grade.

BOOK REVIEWS

GEOLOGICAL EXPEDITION TO BRAZIL AND CHILI

By J. B. Woodworth

(*Published as a Bulletin of the Museum of Comparative Zoology at Harvard College*)

The report of the first Shaler Memorial Expedition is of interest not only on account of the value of the observations and studies recorded in it, but also from its association with the memory of Professor Shaler, the first Dean of the old Lawrence Scientific School. The expedition whose results are herein recorded was undertaken by means of the income from an endowment fund raised by alumni of Harvard University in honor of Professor Shaler, and was conducted by Professor Woodworth to Brazil for the purpose of exploring the Permian conglomerates of a part of the region, the glacial origin of which had been advanced.

The first part of the report is a general description of the route followed for the purpose of recording numerous observations, and without any attempt to describe the main object of the journey. The region from Rio de Janeiro for some distance inland is described in detail and the numerous observations of the author set down in such a way as to make most interesting reading of a scientific report. Not only is the geology of the re-

gion described but the various fauna and flora encountered are carefully noted. After studying this region the itinerary was through the straits of Magellan to Southern Chili. Concepcion and Santiago were visited, and at Valparaiso the effects of the earthquake were studied.

The second part of the report deals more particularly with the geology of Southern Brazil, especially as relating to glacial deposits of the Permian or late Carboniferous period. It is thought that at this time glaciers operated in regions much nearer the equator than in the last glacial epoch, with which we are most familiar. Excessive storms of hail are suggested as affording a possible means for precipitating ice in a region where snow never falls. The Triassic Trap Plateau and the Geomorphology of South Brazil are also treated in this part of the report.

Perhaps the most interesting portion of the report from an engineering standpoint is the Note on the Changes of Level of the Coast of Southern Chili. In this is given a comprehensive outline of the theories of Suess, Lyell and Darwin, particularly the numerous observations of the latter in this same region. The author himself did careful work on the subject and the results of his investigations of the raised beaches and other evidences of elevation lead him to conclude that in various parts of the coast there has been an elevation of from 10 to 45 feet in comparatively recent geologic time.

The report is at all times interesting, presenting much data of scientific value, and affords considerable information about a country the characteristics of which are not generally known.

RATIONAL AND APPLIED MECHANICS

By Calvin Morton Woodward

(*Professor Emeritus of Mathematics and Applies Mechanics, Washington University, St. Louis. Published by Nixon-Jones Co., St. Louis. Price,* $4.00)

This book is written for students entering upon their second collegiate year, and is intended to be read ("always with pencil and paper at hand"), without the aid of a teacher. The charac-

teristic feature of the book is its excellent choice of materials, and the large number of illustrative problems which are worked out in detail. The most striking lack is the absence of the usual body of problems to be worked out as exercises by students. In the opinion of the author it is better to secure such problems by a "personally conducted tour of a few hours through the shops, yards, and mills" of the student's own neighborhood.

As an example of book-making, the work is not up to the standard set by the more careful of the publishing houses. A whole page of errata is supplied with the first edition, and the most casual inspection reveals numerous further misprints, such as "back words" for "backwards" on Page 491.

The plan of the author has been to give an introduction to a large number of fields rather than to pursue any one direction very far. The treatment throughout is fresh, vigorous, and sane. The contact with reality is close, and the distinction between idealized problems and practical conditions is constantly emphasized. The author is a man who has had not only a long and distinguished career as an engineer, but also a long and very successful experience as a teacher, and the book shows the marks of the real teacher on every page. One might wish that an outline of the few essential methods had been succinctly stated in the form of a summary, and that the method of "isolation" had been used more consistently; but these are defects which seem to be common to all text-books in this subject.

The book as a whole will certainly exert a wholesome influence on the teaching of mechanics.

TEXT BOOK OF MECHANICS. VOL. IV, APPLIED STATICS

By L. A. Martin

(*Published by John Wiley & Sons, N. Y., 1913*)

This is the fourth of a set of five small volumes intended to cover a thorough two year course in mechanics for engineers. The preceding volumes are I—Statics, II—Kinematics and Kinetics, and III—Mechanics of Materials. The remaining volume, V—Applied Kinetics, is promised shortly.

All of these books are very good. They have been made small by selecting, usually with good judgment, only such material as is important. They are clearly written and well illustrated.

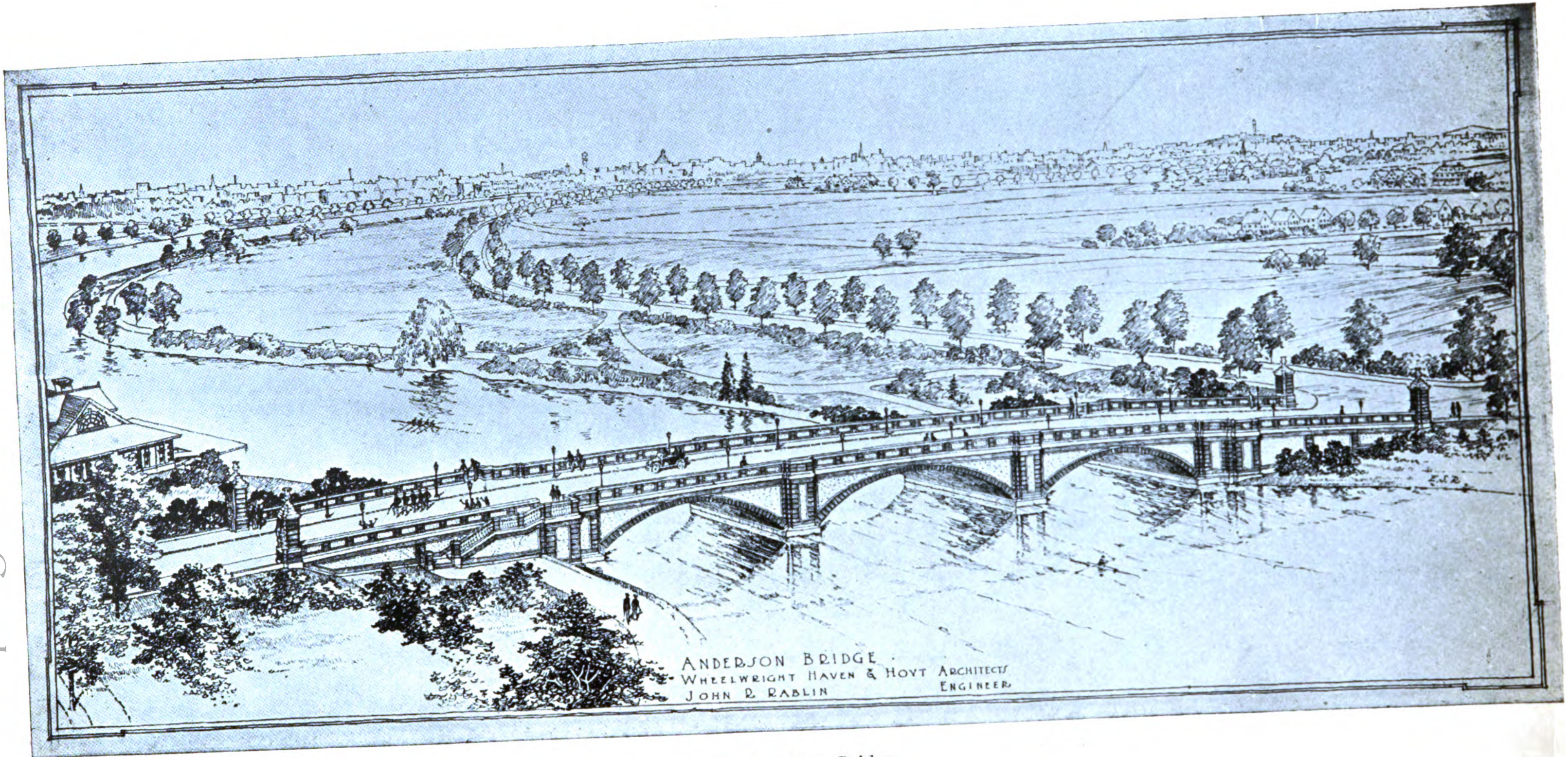
Certain of the best features of the volume under review are characteristic of the series as a whole. Chief among these is the insistence on the "principle of isolation." Martin frequently says, "Show so and so as a free body," meaning draw a picture of it with all other bodies removed and their action on it represented by appropriate arrows. This enforces a clear distinction in the reader's mind between action and reaction at a point of contact, and between external and internal forces, and makes the subsequent application of the fundamental conditions of equilibrium easy. These conditions are admirably summarized in Chapter II of this fourth volume, but strangely enough, the analytic formulation of them is not displayed in black type.

The outline of the book is in general excellent. The only questionable feature is the inclusion of a chapter on work and power in the volume on statics. It is true that the methods used in such cases are essentially statical, but the reason for this is best shown in connection with Kinetics, and the chapter in question seems strangely isolated.

The detail of "Applied Statics" is in general very good. Thus the sections on dynamometers, belting and journal friction, and the careful treatment of abutment reactions are well done. But this excellence in detail is not uniformly distributed. Thus on pages 107-109 there is a long investigation of the wedge, which is not linked with a different treatment of the same subject in an earlier volume. On pages 17-21 there is a long and useless treatment of an indicator card on the false assumption that the expansion line is a perfect-gas isothermal. These are only typical of many other unnecessary imperfections in an otherwise excellent book.

Finally, it is to be regretted that throughout this series, the "slug" is used as a unit of mass instead of the pound. The net result of such teaching is to leave a student with the idea that the phrase "per unit mass" always means "per slug," whereas it never does mean that outside of the mechanics class room.

H. N. Davis, *Assistant Professor of Physics.*



The Anderson Bridge

(Courtesy of "The Architectural Review")

HARVARD ENGINEERING JOURNAL

A QUARTERLY

Devoted to the interests of Engineering in Harvard University

THE OFFICIAL ORGAN OF THE ASSOCIATION OF HARVARD ENGINEERS

VOL. XII — JUNE, 1913 — NO. 2

THE ANDERSON BRIDGE

CHARLES W. KILLAM

Assistant Professor of Architectural Construction

This new bridge, now under construction, will carry Boylston Street in Cambridge across the Charles River, connecting with North Harvard Street in Boston near the Stadium. It replaces an old narrow wooden drawbridge.

The bridge proper is the gift of Mr. Larz Anderson, '88, in memory of his father, Nicholas Longworth Anderson, '58, a major-general in the Civil War. The approaches are paid for by the cities of Boston and Cambridge.

The new bridge will give long wished for relief from the annoying congestion of the great crowds pouring out from games in the Stadium, numbering, in some cases, 40,000 people. Most of these thousands have had to walk up the muddy street, cross the old wooden bridge with a draw only about 20 ft. wide at its narrowest part, and then continue in the mud up Boylston Street. Boylston Street is 60 ft. wide, and this width will be maintained over the bridge, giving roughly three times the width available heretofore. It is to be hoped that the remaining point of congestion, the gates from Soldiers Field, may also be widened in some way. The bridge will have a 40 ft. roadway and two 10 ft. sidewalks. Boylston Street is likely to be an important inter-suburban road, and the structure has been designed to carry

electric car tracks if required in the future. Last, but not least, the new bridge will redeem the river from the blemish of the old structure, which was entirely out of harmony with surroundings which are being made more and more presentable.

Architecturally, the bridge has been designed with careful attention to the surroundings. The nearest building is the Weld Boat House, of stucco on brick, with brick quoins and red tile roof. The power station of the Boston Elevated Railway, and the Freshman Dormitories now being built next to it are of brick, as are most of the University buildings. The wall around the sunken yard of the Boston Elevated Railway and the posts of the Soldiers Field fence are of concrete with brick quoins. These surroundings all suggested a concrete bridge with brick trimmings and these materials have been used with simple classic details in harmony with most of the University buildings.

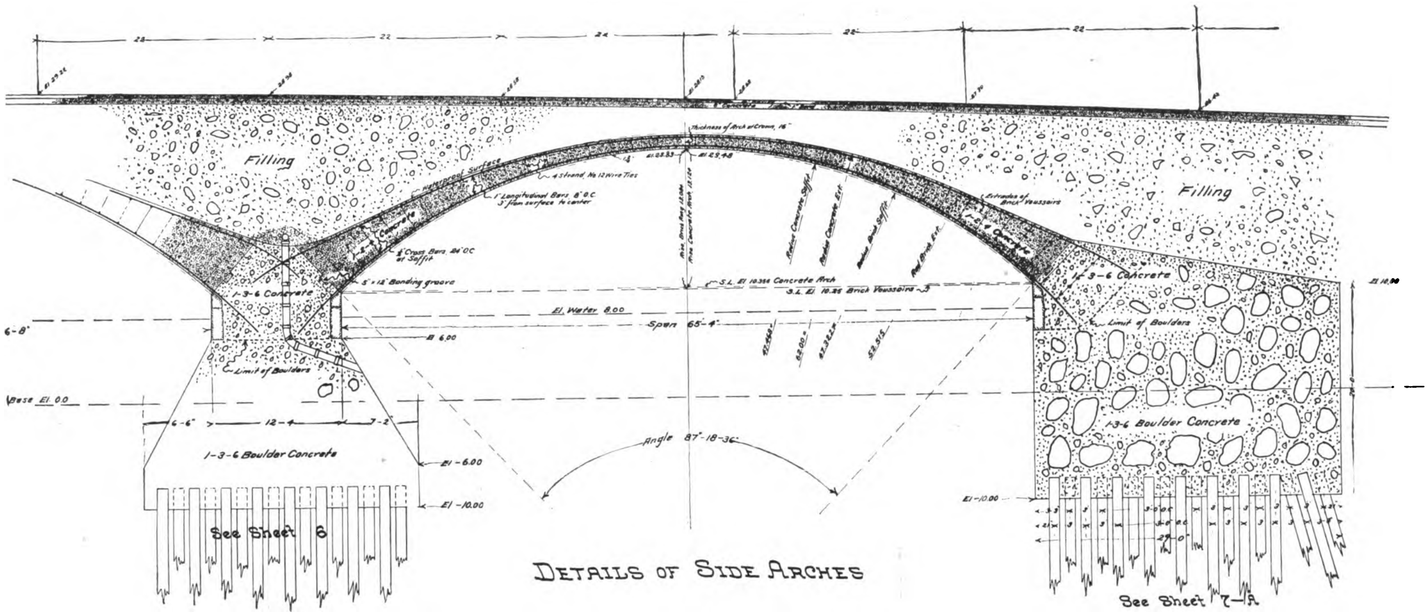
The loads used in the calculations were as follows:

Dead loads—
Earth filling, 120 lbs. per cu. ft.
Concrete, 150 lbs. per cu. ft.

Live loads—
400 lbs. per sq. ft. assumed for two conditions:

I. Uniform load for the whole span.
II. Uniform load over one-half span. This includes provision for electric cars weighing 50 tons.

There are three segmental arches of reinforced concrete, with solid spandrels retaining filling. The middle arch is 76 ft. 8 ins. in the clear and the side arches 65 ft. 4 ins. and the river piers 12 ft. 4 ins. wide, making the total span between abutments about twenty feet wider than at present. The springing line is about two feet above water level and the middle arch is about sixteen and a half feet above the water line and the side arches about a foot lower. Two 30 in. water-pipes are carried across the bridge, which, with necessary clearance for paving, raise the grade at the middle of the bridge to about twenty-one feet above the water. This requires a vertical curve over the bridge and approaches with a maximum of 4°, and necessitates some slight

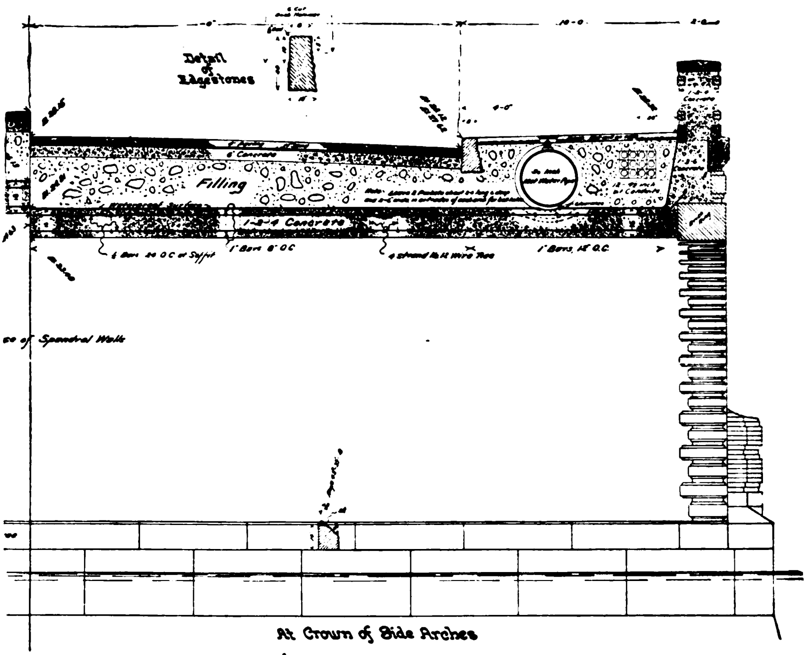


Longitudinal Section

Scale 1/4"=1'

Details of Side Arches, Longitudinal Section

changes in grades at the junction of North Harvard Street and Soldiers Field Road on the Boston side, but starting from the present grade of Charles River Road on the Cambridge side The approach on the latter side will be raised so far above the river promenade that steps will be required to reach it; and on the side toward the Weld Boat House the present timber river wall will be replaced by a sloping bank to the water level.



Cross Section at Crown of Side Arches

The middle arch is 18 ins. thick at the crown and about six and a half feet at the springing, reinforced longitudinally near the intrados and extrados with 1 in. deformed bars of medium steel, 8 ins. on centers under the roadway, and 12 ins. on centers under the sidewalks. The side arches are the same except that the arch is 16 ins. thick at the crown and about five and a half feet at the springing. The concrete for the arches is to be laid

in transverse sections, starting simultaneously from both haunches. The arch rings are faced with brick voussoirs extending back into the arch about four feet.

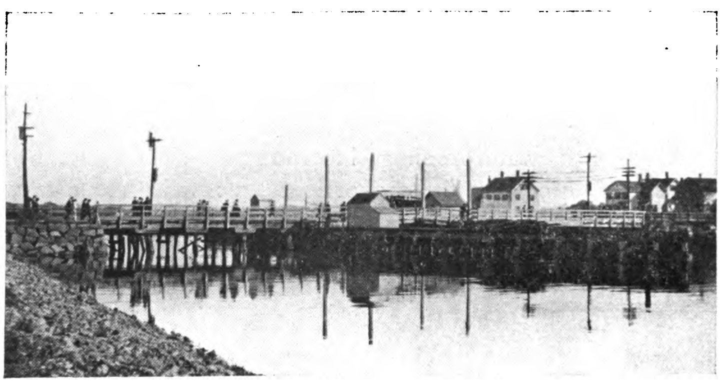
The river has a maximum depth of about fifteen feet with about ten feet of gravel, then a layer of blue clay overlying hardpan. The remains of what appears to be an old corduroy road have made the dredging difficult in places. The substructure is of concrete on wooden piles about two feet apart driven through the blue clay into the hardpan. They are cut off 18 ft. below water line and the concrete enclosing them extends 2 ft. below their tops. The concrete is to be deposited inside cofferdams built of 6 in. splined sheet piling driven down into the clay. The concrete for this substructure is mixed in the proportions of 1:3:6 with boulders up to 4 cu. ft. in volume allowed up to the line of the ends of the arch reinforcement. All the concrete below the water line has a facing of 1:2 mortar 1 in. thick with waterproofing incorporated. The concrete for the arches is mixed in the proportions 1:2:4 with stone to pass through a 1½ in. ring.

The spandrel walls are of plain concrete of gravity section, and are specified to be constructed after the centers of the arches have been struck. They are provided with vertical expansion joints at their junctions with the piers and along the extrados of the arch. These joints have two layers of felt laid in hot waterproofing compound. They are so arranged as to be concealed by breaks in the back trimmings.

Besides the trimmings of brick there are granite courses at the level of ground and water and cast stone is used for belt courses, parapet copings, steps, balusters, etc. The surface treatment of concrete has been carefully specified. Spandrel, wing, and parapet walls are to have a surface layer applied with the mass, of 1:1:2 mixture, the two parts being marble chips or crushed stone between ⅛ and ¾ in. Waterproofing material will be added. After the concrete has set for 30 days it is to be picked or pointed. The arch ring has a surface of 1:1 mortar, 1 in. thick, built up with the mass and to have a wash of 1:2 grout brushed on after the forms are removed. The surface is

then to be rubbed with carborundum to remove marks and fill pores, then to be scrubbed down with brush and water. The cast stone is to be composed of 1:3 marble or crushed stone chips not over ⅜ in. and with waterproofing incorporated. The surface after setting from 40 to 60 days to be six-cut. The mortar for cast stone joints is to be 1:2 Portland cement. The outer 4 ins. of brickwork is to be laid in Puzzolan cement and the rest of the brickwork in 1:3 Portland cement mortar. One pail of lime putty may be added for each barrel of cement.

Wheelwright, Haven & Hoyt were the architects employed by Mr. Anderson to design the bridge. Edmund M. Wheelwright,



The Old Stadium Bridge

'76, who died in August, 1912, was a well known and popular Harvard man, a founder of the Lampoon, formerly City Architect of Boston, and architect of many important buildings including, in Cambridge, Randall Hall and the Lampoon building. He had large experience in bridge design, having been consulting architect for many bridges around Boston, for the stone bridge across the Connecticut at Hartford, and for the West Boston Bridge, and was one of the advisory board of architects of the Boston Elevated Railway which was consulted in the design of the Viaduct at the Dam of the Charles River Basin. The engineering design and superintendence are in the hands of the Metropolitan Park Commission, John R. Rablin, Chief Engineer.

The contractors are the Holbrook, Cabot and Rollins Corporation of Boston. The contract calls for the completion of the bridge by September 30, 1913. At present, May 1, the substructure is well along with the exception of the Cambridge abutment where the underground obstructions have made dredging and piling difficult.

The total cost of the bridge will be about $200,000, which includes engineering, but not architectural, services. Of this sum an amount up to $30,000 can be charged to the two cities for the actual cost of the approaches.

This bridge, as well as the Viaduct and the West Boston Bridge, give encouraging evidence that architects and engineers can coöperate in the case of engineering structures in conspicuous positions, to combine utility with beauty and conformity to surroundings.

THE IMPROVEMENT OF THE NEPONSET RIVER IN MASSACHUSETTS

SECOND ARTICLE

EDMUND M. BLAKE, '99

[NOTE.—The first article on this subject, which appeared in the November, 1912, number of the JOURNAL, was prepared by the writer in the late Spring of 1912. Between the dates of writing and publication, changes were made in the plans and estimates, and construction work was not begun until November, 1912. The contract, as finally executed, covers about 300,000 cubic yards of earth and 800 cubic yards of ledge excavation and provides for completion of all the work on or before November 15, 1914. The corresponding statements in the first article are, therefore, subject to the above corrections.]

On the 16th of October, 1912, the Massachusetts State Board of Health executed a contract with the Barge Canal Construction Company of New York City, for dredging and improving the channel of the Neponset River in the towns of Milton, Dedham, Canton, Westwood, Norwood and Sharon and the city of Boston. under the provisions of chapter 655 of the Acts of the year 1911. Early in November, 1912, the contractor began the shipment of material and machinery for a dipper dredge, which he started to erect in the first week of December at a favorable spot on the banks of the river, opposite the old Hyde Park Pumping Station below the Readville yards of the N.Y. N.H. & H. Railroad. The steel hull was launched on December 10, but it was not until January 17, 1913, that the machinery was all in place and housed in. A still further delay was caused by the Massachusetts Board of Boiler Rules, who finally declined to approve the boiler for the operating pressure required. This ruling made the removal of the rejected boiler and the installation of a new one necessary. The actual work of dredging did not, therefore, begin until Tuesday, January 28, 1913, since which time dredging has been carried on without interruption, except at infrequent and short intervals for repairs. The work is not affected seriously nor the rate of progress reduced appreciably by ice up to 10 inches in thickness or by severe winter weather, as the boiler, engines and

all operating levers are housed in. A complete dynamo plant lights the dredge and the daily progress is about doubled by working two eight-hour shifts, the first from 7.00 A.M. to 3.30 P.M. with one-half hour off, and the second from 4.00 P.M. to 12.30 A.M., with one-half hour off.

A brief analysis of the reasons for the long delay in starting the actual work of dredging will bring out a point of direct interest to engineers engaged upon similar work. The profile of the Neponset River is very flat with many high intermediate points, tending to check the velocity of flow at intervals and resulting in the deposit of suspended matter, much of which is known to enter the river from the mills and factories in the towns of Norwood, Walpole and Canton. The contributing watershed at the lower end of the Meadows is about 95 square miles, largely with a sandy gravel surface. The effect of back water from the flashboards on the dam of the Mattapan Paper Mills, the lower terminus of the work, is felt upstream for a distance of several miles. The original surveys of 1895 and 1896, on which the plans and estimate of the Report of 1897 were based, were made under a rather limited appropriation. The cost, as estimated at that time, was $127,115. When the Act came up for passage in 1911, fifteen years later, this amount was raised to $150,000. The results of the complete surveys of 1911 and 1912 showed that at least 75,000 cubic yards of material had been deposited in the river during that period of fifteen years or at the rate of about 5,000 cubic yards per year. The determination of this increase in yardage was based upon the cross sections and bottom grades of the 1895 and 1896 plans and surveys.

In an attempt to accomplish the results demanded by the Act of 1911 under its appropriation of $150,000, many plans for the improvement of the river were studied and completed in detail, many additional rainfall and runoff studies were made and much additional data was obtained in the field.

The first call for bids was set for August 26, 1912, upon which date bids were received from three firms. The lowest bid (that of the Barge Canal Construction Company) was for $159,900, and the highest was for $237,000.

These bids were all rejected because they exceeded the appropriation. The time of completing the work was then extended one year; the original specifications were changed in several clauses which would reduce the cost of dredging without affecting the hydraulic results, and new bids were called for on October 3, 1912. Calls for bids, and specifications and plans were sent to thirty-six contracting firms and individual contractors. Bids from six firms were received, the estimates for the work ranging from $115,950 to $181,600. The Barge Canal Construction Company submitted the lowest bid.

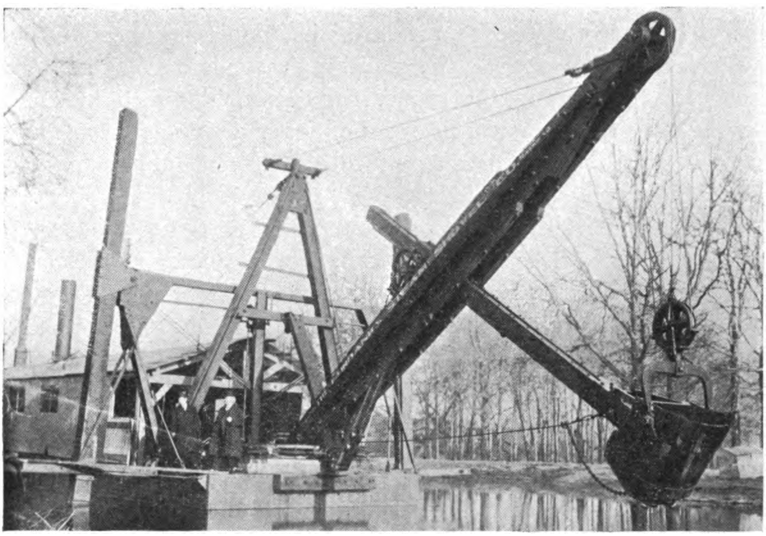
The prices per cubic yard of material removed, on which the Barge Canal Construction Company based their bid, are as follows:

Soft Material, 42c.
Hard Material, 42c.
Boulders, $7.50.
Ledge Rock, $7.50.

Bids were compared on the basis of 130,000 cubic yards of soft material, 130,000 cubic yards of hard material, 100 cubic yards of boulders, and 800 cubic yards of ledge rock.

The cost of engineering, allowances for extra work on bridges and pipe lines, possible overhaul charges and various contingencies, added to the lowest bid received, still left the total in excess of the appropriation. A conference was then held with the officials of the various towns affected and the City of Boston, as a result of which the Board decided to let the contract to the lowest bidder, the Barge Canal Construction Company, with the provision that the work covered by the contract should be limited to that part of the total appropriation of $150,000 available for dredging, unless the Legislature of 1913 should make an additional appropriation. The Board has already petitioned for such an appropriation of $35,000, which will enable it to complete its comprehensive plan for the improvement of the Neponset River from the dam of the Mattapan Paper Mills in Hyde Park up to a point below Pleasant Street in the town of Norwood, as required by the Act of 1911.

The contractor's plant at present consists of a large coal scow and one steel dredge of the dipper type, built by the Fairbanks Steam Shovel Company, of Marion, Ohio. Coal is stored at points accessible to the river where it is loaded into the scow and towed up or down stream to the dredge. Its capacity is about 15 tons. The dredge consists of a steel hull, 70 ft. long, 18 ft. wide, and 6 ft. deep, made up of 10 transverse sections each 7 ft. long, bolted together and braced inside with longitudinal and transverse steel plates and beams. In the stern is an



The Dipper Dredge, showing 60-foot boom and 1¼ yard dipper. Taken in January, 1913

extended steel frame to carry the stern anchorage spud. In the bow is a heavy A frame to carry the boom, the dipper and the cables and two vertical steel frames with lateral extensions for the two forward anchorage spuds. The boom, built of heavy oak, is 60 ft. long and turns on a half circle roller way. The dipper arm, 40 ft. long, carries a heavy steel dipper with a full load capacity of about 1.25 cubic yards. In ordinary digging the dipper is fitted with a hardened steel jaw for which four very

heavy hardened steel teeth are substituted when the material encountered is cemented gravel or hardpan with boulders.

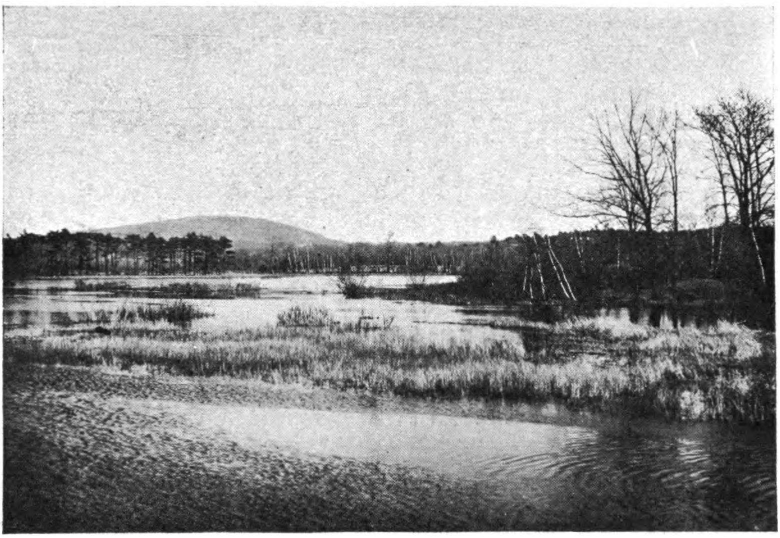
The boiler is of the horizontal marine type, Continental pattern, of 50 boiler horse-power. When operating two eight-hour shifts, the coal consumption is approximately 2 tons per 24 hours, including banking charge. The machinery consists of the hoisting and turning engine with its drums for boom and dipper, two small spud engines for the forward and stern anchors and a small engine and dynamo for electric lighting. The anchorage spuds are driven into the river bottom when operating to offset the dipper reaction when the latter is loading, swinging and dumping. To move the dredge forward, the dipper is embedded in the river bottom ahead, the anchorage spuds are lifted, the dredge is floated and the dipper cable is then pulled in, thus moving the dredge forward with the dipper acting as an anchor. In this way, the entire dredge, which displaces about 150 tons, is easily and precisely handled.

Tests made of the speed of operating in a fairly hard, sandy gravel, bordering on cemented gravel, showed an average of very nearly 14 dipperfuls, containing approximately 1 cubic yard each, handled in seven minutes, or at the rate of about two per minute. One test showed 76 dipperfuls handled in one hour, including three runs ahead, each run taking about five minutes and covering about 10 feet in distance. When not hampered by trees along the banks and in ordinary hard material, it is expected that the capacity of the dredge, working on two eight-hour shifts, will approximate 20,000 cubic yards per working month on this particular contract.

At the time of writing this article, one estimate has been made, showing 5,636 cubic yards removed in the eighteen working days from January 28 to February 14, 1913, both inclusive, or at the average rate of about 315 cubic yards per day of two eight-hour shifts. In explanation of this apparently small average daily quantity, it should be cited that much of the work covered by this first estimate was on a stretch of the river where a large part of the banks was lined with trees on land of the Metropolitan Park Commission, the preservation of as many as possible being imperative; and, furthermore, that the material in

this section was over 50% cemented gravel, bouldery gravel and hardpan with some blue clay—the hardest material to be encountered in the entire work. Under these circumstances an average of 315 cubic yards per day of two eight-hour shifts is very satisfactory.

The contractor is paid for 6 ins. outside of and below the grades and side slopes given him by the engineer if he removes it, but he must get at least to the grades and lines given. The few final soundings so far made indicate that he will probably



The Neponset Meadows below Big Blue Hill, near Dedham Road. The flood conditions shown will be eliminated by the new channel. Taken in March, 1912

average from 6 ins. to 10 ins. below grade, which is close work for dredging in a flowing river. Boulders less than 9 cubic feet in volume are included in earth excavation. One boulder has been removed by the dipper, containing two cubic yards, and a number ranging from 14 to 20 cubic feet.

In the original soundings and estimates, earth was classified as "hard" and "soft" material. The contractor's bid was the same for each, which will result in a great saving in engineering work in the field.

The contractor is to install in the immediate future a second dredge, of the floating derrick and orange-peel bucket type, to handle the excavation through the settled district in Hyde Park where a large number of bridges and pipe lines will interfere with the work. It is also his plan at present to install a third dredge, of the dipper or hydraulic suction type, at the upper end of the meadows, in the spring, to work downstream toward the present dipper dredge.

In conclusion, a brief analysis of the study and treatment of the problem from the standpoint of river hydraulics may be of interest:—

1. All of the available rainfall and runoff data bearing upon the watershed was carefully studied. In this case the data ran back to 1889.

2. Similar data on watersheds in eastern Massachusetts in any way comparable with the Neponset watershed was studied.

3. The results available from twice-daily readings at eight or ten river gages were analyzed.

4. The topography and forestration of the watershed were examined and studied.

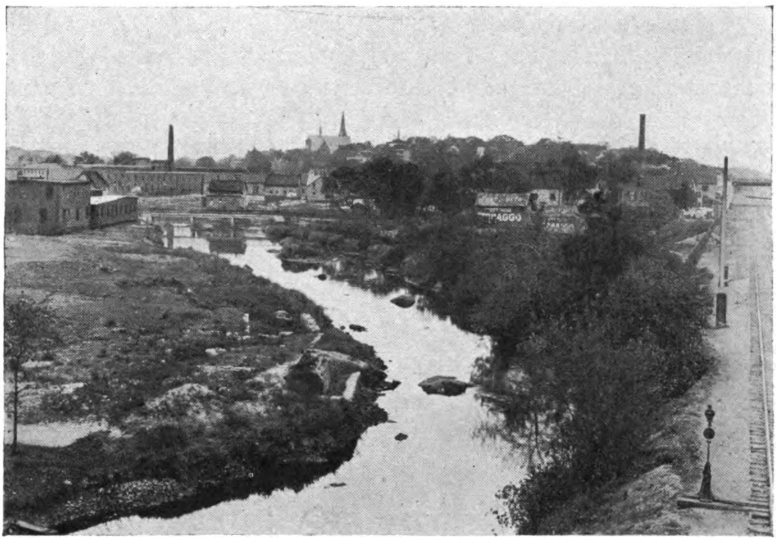
5. The storage effect of approximately 4,000 acres of meadows, now flooded each year, was investigated.

6. That part of the river to be improved was divided into drainage divisions, the division points coming at marked changes in watersheds, generally at or near the entrance of tributary streams.

7. As a result of all these studies it was decided to provide a channel with a maximum carrying capacity of 4 second-feet per square mile of watershed, it being determined with apparent justification that the runoff would not exceed that quantity oftener than once in 12 or 15 years, after the first of April or before the middle of November. This determination to provide for 4 second-feet per square mile of watershed was the principal problem. The balance of the work of hydraulic computation was the selection of channel cross-sections in the different drainage divisions which would fit in with the ranges in head available with a minimum of excavation, but particularly with the

object in view of providing a sufficient depth and velocity in periods of low flow to prevent the growth of aquatic plants and river grass.

8. The Chezy formula for velocity, $V = C\sqrt{rs}$, and the Ganguillet and Kutter formula for C were adopted, the calculations being made by use of the valuable diagrams of "Mean Velocity of Uniform Motion of Water in Open Channels," pre-



The Upper Ledge Section on the Neponset River, looking down stream from Glenwood Avenue to the B Street Footbridge in Hyde Park. Taken in October, 1912

pared by Mr. Irving P. Church. The value of the coefficient of roughness, N, was finally taken as 0.035 in all computations. This rather high value appeared to be justified for two principal reasons:

a. There are many sharp bends, both single, reverse and double reverse, in the river which, for one reason or another, it was decided could not be straightened by the use of meadow cut-offs.

b. A new channel dredged in a flowing river, especially with the physical characteristics noted above under "*a*,' will be left with a more or less irregular and uneven bottom.

9. Losses of head at five railroad bridges, two trolley bridges, two foot bridges and five highway bridges were carefully investigated, for the channel had to be changed immediately above, under, and immediately below most of these bridges, there being no funds available for removing bridges and replacing them with modern structures adapted to a uniform channel.

The work of dredging through the Hyde Park district will necessitate the lowering of two 10-in. water mains, one 4-in. feed water intake and one 16-in. cast-iron sewer. The most difficult obstruction encountered is a group of pile bridges in the yards of the N.Y. H.H. & H. Railroad, below Readville, where over 300 piles are driven into the river bed without uniform centering. The final treatment of this group has not yet been decided upon, but at high flow there is a loss of about four inches of head at this point.

The work is under the supervision of Mr. X. H. Goodnough, Chief Engineer of the Massachusetts State Board of Health, with the writer as Engineer-in-Charge. The engineering assistants are Mr. Newton L. Hammond, Mr. Ernest F. Davis, Mr. Harry S. Wright and Mr. William G. Norteman. The Barge Canal Construction Company is composed of Mr. Charles Longenecker, Mr. George W. Beeman and Mr. Louis B. Harrison.

ENGINEERING SPECIFICATIONS

JOHN BIRKINBINE
Consulting Engineer, Philadelphia

Specifications descriptive of constructions, usually supplementary to or explanatory of drawings, are accepted as good engineering practice, and a few suggestions drawn from extended experience are offered to the readers of the HARVARD ENGINEERING JOURNAL, not as a general discussion of specifications, nor as a collections of "don'ts." The purpose is to enumerate some features which may aid in appreciating the functions of specifications, and the relation of the engineer to these.

Specifications as a rule refer to three parties:

(*a*) The contractor, individual, firm or corporation who or which undertakes to complete the structures described, generally furnishing bond to secure the fulfilment of the contract.

(*b*) The contractee or individual, firm or corporation, for whom the work is to be done, and who agrees to compensate the contractor, at prices or rates and upon terms specified in the agreement.

(*c*) The engineer who has drawn or accepted the specifications as a guide, and who ordinarily is compensated as a representative of the contractee. But the practice is, to make the engineer the arbiter in case of dispute or disagreements affecting the intent of the specifications, the satisfactory character of the work done, or material supplied.

In signing a contract of which specifications form a part, the contractor accepts the engineer as arbitrator, thus making him more than a representative of the contractee, and placing upon him the duty of dealing equitably with both principals to the contract.

The willingness with which contractors accept the arbitration of engineers, of whom they have little if any personal knowledge, is a tribute to professional integrity, which should encourage the maintenance of a high standard of ethics.

To properly prosecute construction some one must be in authority, and in specifications such authority is usually placed upon the engineer, often with power so drastic as to place contractors at a disadvantage if the engineer fails to appreciate that both parties have accepted him as arbiter, and thus recognized the honesty and ability of the profession. It is claimed with truth that severe penalties may be necessarily provided in specifications to secure good service from contractors seeking to gain advantage by what may be termed sharp practice, and in such case the engineer must be on the alert to protect his principals and yet do justice to the contractor.

The problems to be adjusted in the event of disagreements are often most troublesome, but as a rule close adherence to specifications limits the difficulties and reduces the probabilities of litigation; a most unpleasant and expensive sequel of some contracts. Such adherence may at times prevent modifications which appear desirable, as changes in accepted plans or specifications may open avenues for future annoyance.

A few illustrations of deficiencies in specifications are offered as of possible interest and value.

Prescribing unnecessary tests or those which are not expected to be applied, or physical features based upon claims of manufacturers, that certain products exceeded the requirements which they were designed to meet, have at times made specifications impracticable by demanding as a minimum what the producer announced as his maximum.

An illustration of an impracticable test was repeatedly heating fire-brick to a white heat, with sudden intermediate quenchings in cold water; treatment which would destroy the value of a brick with fine resisting qualities.

Thorough familiarity with, and rigid adherence to specifications, gives to the engineer decided advantage, for too often details of these are overlooked or forgotten, until some disagreement or litigation brings them into notice, and any change, unless formally agreed to, and recorded, may vitiate a contract.

Therefore, thought and care devoted to the preparation of specifications is demanded as a preventive of trouble.

Many disagreements, disputes or litigations are the fruits of unfamiliarity with the specifications, which in many instances are only studied in advance of contracting, and consigned to pigeon holes until such time as they become factors in adjusting differences which would have been prevented by an intimate knowledge of the detailed requirements.

As specifications are prepared as a guide for competitive bidding, rigid insistence upon their provisions is no hardship on a contractor who accepts them as a basis for his bid for subsequent work, and laxity in enforcing the requirements is an injustice to unsuccessful bidders.

An item often omitted or imperfectly set forth in specifications, is a proper explanation of the purpose or use of the construction described; an omission which may be illustrated by the following:

A large reservoir built for a municipality proved defective, and in the course of a suit brought against the contracting firm, its attorney cross-questioned the engineers of the municipality upon the specifications until his repetition brought a protest from the opposing lawyer, and a suggestion from the judge to conserve time. The purpose of these repeated references to details in the specifications developed, when the contractor's attorney asked for a non-suit, on the ground that the testimony submitted showed that nowhere in the specifications was the reservoir required to be "water-tight" or to "hold water."

Although the request was denied by the court, the importance of having specifications indicate the function of the construction was emphasized, for any deficiency subjects the instrument to adverse criticism or to attack, and while in the case cited the definition of the word "reservoir," and its connection with a public water supply system, was accepted as indicating the use to which it was to be put, the omission referred to supplied ground for assailing the specifications.

The desirability of giving full information as to details or methods, material or workmanship, encourages extending specifications so as to become prolix with a tendency to repetition or possible want of harmony. To cover elementary essentials with-

out unnecessary verbosity and possibilities of conflicting statements, is a problem which confronts the engineer in drawing specifications.

A story is told of an uneducated contractor who, as the lowest bidder for some municipal work, when interviewed by the authorities and asked if he had read and understood the specifications replied "No, my clerk did that, but if I can't drive a two horse team through seventy printed pages of specifications I am no contractor."

While the contractor's criticism may have been unfounded, it bluntly explains the prevailing opinion concerning prolix specifications, but length is preferable to brevity which makes clear description impossible.

Phraseology may often be abridged without detracting from the perfection of specifications, by omitting details of requirements of materials for which standards have been adopted by Engineering Societies, and referring to these standards as the bases of what is to be supplied.

Most of these authoritative standards have the advantage of endorsement by producers and users, and they greatly limit the impracticability of harmonizing uncertain physical and chemical requirements. The extent to which specifications for material are affected by demanding both chemical compositions and physical tests without knowledge of how these harmonize, by designating methods of manufacture and characteristics of resulting product, without experience as to what is to be expected, need not be discussed here.

The injunction that "all material and workmanship must be of the best quality and character" or phrases of similar intent, are often supplemented by specific requirements, which may be carried to an impracticable extreme. On an important government construction the specifications indicated physical features in metal, which, if insisted upon would have greatly increased the cost, for the failure of any one piece worked condemnation of an entire cast. The engineer in charge expressed surprise when a manufacturing concern made this point, for he claimed to have based his requirements upon a printed statement of the same concern to the effect that it had produced such material.

The fact was, that having made some intricate castings which exceeded the severe specified requirements, the casting makers advertised this result as a special achievement, but the engineer practically made the manufacturer's maximum the minimum requirement of his specification.

The incorporation in a specification of compositions, tests or qualities which the engineer is not in position to verify, is a feature to be avoided, and only such requirements as the engineer is assured that he can have followed should be specified.

Under normal conditions duplication of parts where practicable is advantageous in facilitating work and reducing cost, for excess in quantity may not be more than balanced by those, and in structural work an acquaintance with shop practice, and a knowledge of sizes available, may save time and money.

As the best government is based upon a well matured constitution with which the governed people are familiar and to whose provisions they rigidly adhere, so good engineering work is best secured by carefully prepared specifications with which the parties interested are thoroughly acquainted, so that the requirements can be insisted upon.

ENGINEERING AT THE HARVARD OBSERVATORY

WILLARD P. GERRISH

The modern astronomical observatory presents many interesting problems in engineering. The astronomical instruments of the last generation were the work of the instrument maker, and were built chiefly of brass, even to the bed-plates and frames of the largest telescopes, which were beautifully and elaborately finished and lacquered. The largest instruments of that period would be considered small today, though, strangely enough, their optical qualities compare very favorably with those of the best modern examples. Telescopes of the equatorial type were operated by delicate clockwork driven by weights, and were necessarily of very light construction, in order that these driving weights might not be too heavy to be easily wound up by hand. The telescope of today is very different. It is built in a machine-shop, and is very businesslike in appearance, resembling a sea-coast gun mount more than a mathematical instrument. No money is wasted on display or unnecessary finish. Bed-plates and frames are of cast iron, shafts are of forged steel, and paint is used whenever finish is not absolutely necessary. Great stiffness and solidity characterize the entire structure, the various parts having in many instances a strength eight or ten times greater than would be necessary if failure of material were the only consideration. The telescope with its attached counterpoises, sometimes weighing many tons, is operated by electricity, everything being under the direct control of the operator, who has only to throw a switch, or press a button, to produce the desired motion. The position of the telescope is shown by graduated circles and dials, illuminated by electricity, and indicators are sometimes installed at a distant recording desk for the convenience of the recorder, who operates the instrument from the same distant point by means of electrical connections.

While the simple problem of swinging a great telescope by electricity is not unlike that encountered in any other electrically

operated machinery, special difficulties are presented owing to the high degree of accuracy with which the instrument must be pointed, and the slow, uniform, and precise motion which must be given to it to compensate for the rotation of the earth upon its axis. These difficulties are most apparent when the telescope is used for photography, since the photographic plate retains a trace of every failure of the instrument to follow exactly the object under observation; and if the images in the photograph are to be sharp and circular, there must not be a deviation of more than a few hundredths of a millimeter during the entire exposure, which may be of any duration, from several seconds to as many hours. From this it will be seen that the motion must be not only uniform, but very accurately timed. To accomplish this, the telescope is attached to what is known as an equatorial mounting, the principal feature of which is a short shaft called the polar axis, which is accurately adjusted parallel to the axis of the earth. The polar axis is slowly rotated to keep time with the earth, but in the opposite direction. The heavy mechanism which drives it supplies abundant power, but because of its very weight and power is incapable of keeping time with precision. It therefore becomes necessary to control this heavier mechanism by something much more delicate, for which purpose it is connected electrically with an accurate pendulum, so arranged that at every beat a synchronizing influence is exerted which keeps the telescope moving with an accuracy equal to that of the pendulum. For long exposures even this is not sufficient, since the varying refraction introduced by the atmosphere causes a displacement of the image although the telescope may be driven with perfect precision. For this reason the telescope is provided with "slow-motions," as they are called, which consist of screws or gears by which the instrument may be moved very gradually backward or forward at the will of the observer, who watches a star through a powerful telescope, called a finder, attached to the main instrument. By means of slow-motions the star may be kept steadily upon cross wires in the finder, with the assurance that the main telescope is following with equal steadiness. In the older instruments, the slow-

motions were operated by mechanical means, but in the later types the electric motor has been used very successfully, being operated by push buttons held in the hand of the observer and connected by a short flexible cable. It is the solution of prob-

Mounting of 24-inch Reflector

lems such as these which has developed the modern engineer-astronomer.

The Harvard Observatory, though one of the oldest institutions of its kind in the country, has always been among the foremost in the developments of new methods. Its old wooden

buildings afford an inadequate shelter for some of the most improved apparatus, much of which is original in principle and design. While space will not permit an outline of the methods and equipment as a whole, a brief description of a representative instrument will give an idea of their general character.

The mounting shown in the illustration was designed for the Observatory by the writer, and has the distinction of being the first to be driven by a synchronized electric motor instead of a weight. The telescope is a reflector of 24 ins. aperture, having a focal length of about 11 ft. The complete instrument weighs about 3 tons. The polar axis is seen in the center of the picture, inclined at an angle of about 42 degrees, corresponding to the latitude of the place. It is a steel forging, with accurately ground journals 8 and 4½ ins. in diameter respectively, resting in babbitt-lined bearings, the linings of which are cut away on the bottom for about 60 degrees to insure freedom from the slight rolling motion which takes place in bearings of the usual construction. The axis thrusts at its lower end upon a row of steel balls, behind which is an equalizer to insure distribution of pressure. Friction upon the main journal is relieved by a wheel pressed by a powerful spring against the axis, immediately above the bearing. The pressure of this spring is so adjusted as to relieve the journal of over 90% of the weight which would otherwise come upon it, leaving only enough to insure a firm pressure upon the bearings which are relied upon to maintain perfect alignment. The power wheel at the upper end of the polar axis is 39 ins. in diameter, and is driven by a worm 2 ins. in diameter, with a pitch of ¼ in., making one revolution in three minutes. The worm, in turn, is driven by the motors shown in the foreground. The nearer motor, having the fly-wheel, is the synchronized driving motor; the other is the slow-motion. The motors are connected to the driving worm through differential gearing, so arranged that either or both may be operated, the resultant motion of the worm being the algebraic sum of the two independent motions. The synchronized motor is kept running continually, while the other is run forward or backward at the will of the observer. The telescope itself is of sheet steel, riveted together, and is supported on trunnions turning in bearings at the extremities of a

heavy cast-iron fork, which is bolted to the end of the polar axis. The combination of this motion with that of the polar axis makes it possible to direct the instrument towards any desired point in the sky. Graduated circles 24 ins. in diameter indicate the exact direction in which the telescope is pointing. The main bed casting is supported upon a concrete pier, and is so arranged that it always rests upon three points, and is therefore always perfectly firm. It is, nevertheless, free to move in response to the adjustment screws, seen at the bottom of the picture, by which the entire instrument can be moved so that the polar axis shall be parallel to the axis of the earth.

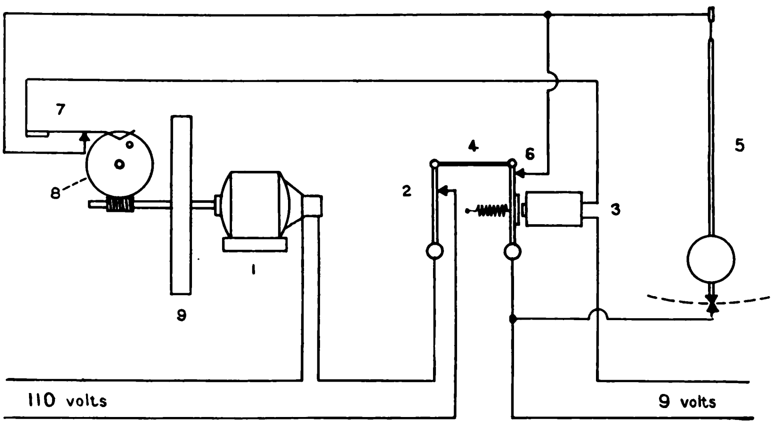


Diagram of Governor

The governor, by which the driving motor is synchronized, is of especial interest. Control is effected by interrupting the current at short, regular intervals, the duration of the interruptions determining the speed. The operation can best be understood by reference to the diagram. The current driving the motor (1), is controlled by a switch (2), operated by a magnet (3), by means of an insulating connecting rod (4). The magnet is connected with a control circuit of low voltage which is closed for an instant every second by a pendulum (5), kept in motion by a suitable clock. The armature of the magnet is provided with a contact (6), operating a shunt, by which the control circuit, once

closed, is held closed until broken by a separate contact (7), called the "cut-off." The time wheel (8), geared to the motor, makes one revolution per second when the motor is running at the prescribed speed, and operates the cut-off upon the completion of each revolution, by the action of a pin upon its rim. Assuming the motor to be at rest, the first swing of the pendulum starts it by closing the power switch (2). The retaining shunt operates at once, holding the power switch closed until the time wheel has moved into the position in which it operates the cut-off. The armature of the motor continues to revolve under the influence of the fly-wheel (9), after the power has been shut off, but at a speed far below the normal. The pendulum again applies the power, which remains on until the time wheel has completed another full revolution. This takes place repeatedly, the speed of the motor increasing with each successive application of the power, and the power interval decreasing owing to the earlier action of the cut-off. The acceleration meanwhile becomes less rapid as the power intervals are shortened, until finally a state of equilibrium is reached, in which the current remains on just long enough to maintain the prescribed speed. Any tendency on the part of the motor to run faster is immediately met by a corresponding shortening of the power interval, while an opposite tendency is met in the reverse manner. The complete cycle of operation is, of course, one second, and in reality the motor, when under control, runs slightly too fast during the first part of the second, and too slow during the last part. The mean speed for the entire second is correct, however, and the influence of the fly-wheel makes the variations so small as to be entirely inappreciable. Practically, the variations of speed may be made as small as desired by increasing the mass of the fly-wheel. The mounting in question is operated with a maximum variation of about 0.2 second, the driving motor using 1 ampere at 110 volts, for an average current interval of about 0.3 second. Experience shows that a normal power interval of from 25 to 50% gives the best results, a longer interval detracting too much from the sensitiveness of the governor, and a shorter one tending to enhance too greatly the effect of any slight tardiness of action due to the varying resistance of contacts.

The electrical system of the Observatory provides a variety of services of different voltage and character, calculated to meet the complex requirements of the scientific and executive work, which may be enumerated as follows:—

220 volt single phase alternating current from the city mains, used for power in the repair shop, and for operating motor generators.

110 volt single phase alternating current from the city mains, for lighting buildings, and operating certain small motors.

110 volt direct current from a motor generator, furnishing power for operating telescopes, and for charging storage batteries.

16 volt direct current from storage batteries, for operating signal and telephone service.

9 volts direct current from a motor generator, for supplying control circuits.

8 volt direct current from storage batteries, for operating fire alarms and standard time signals.

6 volt single phase alternating current from local transformers, for supplying miniature lamps used for illuminating circles and dials at the instruments.

These services are continuous with the exception of the 9 volt and the 110 volt direct current systems, which are used only when the telescopes are in operation, or when the storage batteries are to be charged, at which times the motor generators are started. The 9 volt service operates a great variety of apparatus, some of which is so delicately adjusted that a slight variation in voltage is troublesome. Storage batteries did not prove satisfactory for the purpose because of the constant drop of voltage during discharge, and the effect of their internal resistance under widely varying loads. A compound wound generator did not answer the purpose because of failure to regulate within the necessary limits, owing principally to brush difficulties resulting from the low voltage used. A combination of generator and storage battery was finally adopted, and works very well. The storage battery of four chloride cells was connected in parallel with a compound wound machine, and a standard of 9 volts was chosen, to correspond to the voltage of the

battery when charging at a low rate. The battery is, of course, always charging unless the voltage of the machine falls below the balancing point, in which case the battery discharges, helping to supply the deficiency. If, on the other hand, the voltage of the machine rises, the battery acts as a shunt of low resistance, tending to diminish the voltage impressed upon the outside circuit.

A SIMPLE FORMULA FOR COMPUTING GYROSCOPIC FORCES IN AN AEROPLANE*

EDWARD V. HUNTINGTON

Assistant Professor of Mathematics

The recent letter of Mr. James Means, in *Science* for December 13, 1912, has called renewed attention to the problem of the gyroscopic action of a revolving motor as affecting the safety of an aeroplane. The following simple formula for computing the magnitude of this gyroscopic action is offered as a contribution toward the symposium suggested by Mr. Means.

We shall regard the rotating motor as consisting essentially of a single wheel or disc, whose axle is supported by two bearings at known distances from the center of the wheel.

If the aeroplane is compelled by the rudder, or by a sudden gust of wind, to change its direction of flight, this compulsion may be thought of as due to the pressure of a flat board against the side of the axle, at a point, say, in front of the wheel. As is well known, the axle will resist this pressure on account of the gyroscopic action of the rotating wheel, and will *strive to move off at right angles to the impressed force,* and in so doing, will *strive to carry the whole aeroplane with it.* If the wing surface of the aeroplane is large, this motion will be practically entirely prevented by the resistance of the air, and the result of the gyroscopic action will be the setting up of *internal stresses* in the framework of the machine.

The object of the following formula is to provide a simple means of computing the maximum value of these internal stresses in any given case.

Let $a =$ the distance between the bearings, measured along the axle, in *feet,* and let $P =$ the pressure, due to gyroscopic action, on each bearing, in *pounds.* Then P is given by the following formula:

*Reprinted from *Science*, March 28, 1913.

$$Pa = (0.00034 \ldots) \, Wr^2Nn,$$

where

W = weight of the rotating wheel, in *pounds,*

N = angular velocity of the rotating motor, in *revolutions per minute,*

n = the angular velocity with which the aeroplane is turning out of its path, measured in *revolutions per minute,* and

r = the radius of gyration of the wheel about its axle, in *feet.*

Note 1.—A fair estimate of the radius of gyration can be obtained by a mere inspection of the linear dimensions of the wheel. For example, if the wheel were a homogeneous disc of radius R, then $r = (0.7)R$, approximately; while if all the material were concentrated in the rim, then $r = R$; intermediate cases can be judged by the eye.

Note 2.—The coefficient 0.00034 · · · represents the value of $\pi^2/900g$, where $g = 32$ ft. per sec. per sec. If the lengths r and a are measured in *centimeters* instead of in feet, this coefficient must be replaced by 0.0000112 · · ·. If r and a are measured in *inches,* the coefficient is 0.000029 · · ·.

As an illustrative numerical case, suppose $W = 167$ lbs. (which is the actual weight of a fifty-horse power Gnome motor), $N =$ 1,200 revolutions per minute, $n = 5$ revolutions per minute (estimated), and $r = 2/3$ ft. (estimated). Then if $a = 1$ foot, we shall have $P =$ about 150 lbs.; or, if $a = 2$ ft., $P = 75$ lbs., etc.

It thus appears that under ordinary conditions of flight, the effect of these gyroscopic forces could hardly be serious.

In conclusion, we note the following simple rule for determining the *direction* in which the force P will be exerted. (This rule was first published by the writer in the *Engineering News* for June 21, 1910. (See also *The Scientific American* for November 23, 1912.)

Imagine the deflecting force (that is, the force which compels the aeroplane to change its direction of flight) to be due to the pressure of a flat board against the spinning axle (say in front of the motor), and *note the direction in which the axle, if rough, would tend to roll along the board;* this will give the direction

in which the (forward) end of the axle will tend to move as the result of gyroscopic action—that is, the direction in which the force P will act against the (forward) bearing.

For example, suppose the axle is spinning in the clockwise direction, as seen by an observer looking forward, and let the aeroplane make a sharp turn to the *left;* then the forward end of the axle will strive to *rise.* Similarly, if the aeroplane makes a sharp dive *downward,* the forward end of the axle will strive to turn to the *left.*

HARVARD ENGINEERING JOURNAL

A QUARTERLY

DEVOTED TO THE INTERESTS OF ENGINEERING IN HARVARD UNIVERSITY

THE OFFICIAL ORGAN OF THE ASSOCIATION OF HARVARD ENGINEERS

Published four times during the college year by the Board of Editors of the Harvard Engineering Journal in November, January, April and June.

Subscription Rates

Per year, in advance	\$1.00
Single copies	.35

Advertising rates will be furnished on application to the Business Manager.
Address all communications to the heads of the respective departments:—

HARVARD ENGINEERING JOURNAL,
Room 218, Pierce Hall,
Cambridge, Mass.

Entered at the Post Office, Boston, Mass., as second-class mail matter, June 5, 1902

At the bi-weekly seminar of Engineering C19d (Water Supply Engineering) held in Pierce Hall on May 12, the first steps were taken toward forming a permanent alumni association among the sanitary engineering graduates of the school. The object of the organization is to bring together by a bond of mutual interest

all men who have studied in the school, and are now practicing sanitary engineering. This beginning is not unlike that of the Boston Bacteriological Club, which began in a small way, and has now increased in size and prominence until it is one of the foremost scientific organizations in the country. The Sanitary Alumni Association begins life with but half a dozen members, and since its growth is limited to students who have studied sanitary engineering in the school, it nevertheless should gain prominence in years to come.

That such a movement is on foot shows the great interest in sanitary engineering aroused in those who have studied it at Harvard. Already several men who have taken the courses in the school, have become very successful in the practice of their profession. It is to be hoped that this embryonic organization may mature, and give all men who have been privileged to study under Professor Whipple and his assistants an additional bond of good fellowship and mutual aid.

In connection with the Panama-Pacific International Exposition which will be held in San Francisco in 1915, there will be an International Engineering Congress, in which engineers throughout the world will be invited to participate.

The congress is to be conducted under the auspices of the following five National Engineering Societies: American Society of Civil Engineers, American Institute of Mining Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, and The Society of Naval Architects and Marine Engineers.

These societies, acting in coöperation, have appointed a permanent Committee of Management, consisting of the Presidents and Secretaries of each of these Societies, and eighteen members resident in San Francisco.

The Committee has effected a permanent organization, with Prof. Wm. F. Durand as Chairman, and W. A. Cattell as Secretary-Treasurer, and has established executive offices in the Foxcroft Building, 68 Post Street, San Francisco.

The ten members of the Committee, consisting of the Presidents and Secretaries of the five national societies will constitute a Committee on participation, through whom all invitations to participate in the Congress will be issued to governments, engineering societies, and individuals. The actual management of the Congress and the work of securing and publishing papers will be in charge of the members of the Committee resident in San Francisco.

The Honorary Officers of the Congress will consist of a President and a number of Vice-Presidents selected from among the most distinguished engineers of this and foreign countries.

The papers presented at the Congress will naturally be divided into groups or sections. During the Congress each section will hold independent sessions, which will be presided over by a chairman eminent in the branches of engineering covered by his section.

The scope of the Congress has not as yet been definitely determined, but it is hoped to make it widely representative of the best engineering practice throughout the world, and it is intended that the papers, discussions and proceedings shall constitute an adequate review of the progress made during the past decade and an authoritative presentation of the latest developments and most approved practices in the various branches of engineering work.

The papers, which will be collected and published by the Congress, should form an invaluable engineering library, and it is intended that this publication shall be in such form and at such cost as to become available to the greatest possible number.

The various committees are now actively at work, and it is hoped that further and more definite announcements as to the membership fees, schedules of papers, etc., will be made in the near future.

The Boston Society of Civil Engineers were the hosts of the civil engineering students from Harvard, Massachusetts Institute of Technology, and Tufts on the evening of May 13, at the Boston City Club. Mr. James W. Rollins, past President of the Boston Society of Civil Engineers spoke, giving many interesting and humorous incidents connected with his early

career. Mr. Rollins informed the men present that he realized they were on the verge of the final examinations, and therefore he had chosen a topic which would not greatly burden their minds.

Following the lecture, refreshments were served, and songs and cheers of all three institutions were given with great enthusiasm. Although the Harvard contingent were far outnumbered by the men from Technology and Tufts, they made their presence known, and if sheer enjoyment may be taken as a measure of the value of the evening in bringing the schools together, it was well worth while. The JOURNAL, on behalf of the institutions, extends its hearty appreciation of the kindness of the Boston Society of Civil Engineers.

The following communication, bearing on subjects of immediate interest to all students in the Engineering School, has been received by the JOURNAL.

TO THE EDITOR OF THE JOURNAL:—

Two questions have occurred to me recently as worthy of consideration by the students of engineering, especially the graduates. First, why do we not get together in one dormitory? The advantages are obvious, and as rooms in Conant Hall are reserved primarily for graduate students, these are the ones for which we should apply. This plan was discussed to some extent last year, but no action was taken.

The other question is whether or not a permanent organization of the classes after the manner of the Harvard College Classes, or those of the Law School, would be a benefit. The Association of Harvard Engineers, of course, performs much the same function of keeping track of men, and perhaps nothing more is needed. Certainly not, if it would tend to split interest in the School. But on the other hand, a permanent Secretary for each class might do much to supplement the work of the Association.

The writer believes that both these questions are well worth a thorough discussion.

Ernest L. Robinson, 2G.S.

Few will deny the advantages of a special dormitory for engineering students, and with the recent establishment of the School on a graduate basis, the need for such a dormitory is all the more evident. That such a plan can be carried out with marked success is seen in the case of the Harvard Law School; most of the law students room in certain dormitories which are intended primarily for them, and many of them eat together at club tables at Memorial. In addition to their regular studies, the men eat, drink, and sleep law, and the advantages of this during their three years' course cannot be overestimated.

This custom could easily be introduced into the Engineering School, if its members will but make the effort. It is to be hoped that all men who will be in the School next year will seriously consider this plan of "getting together." Talk there has been; let there now be action.

As regards Mr. Robinson's second suggestion, that for a permanent organization of the men graduating from the School, the JOURNAL suggests that a meeting of those interested be held as early in June as possible, in order that the matter may be discussed, and that definite action be taken, if that is deemed advisable. Will not the writer take upon himself the responsibility of organizing this meeting?

The growing tendency of all modern organizations to concentrate into one highly specialized division what was formerly scattered haphazard throughout a whole department, or number of departments, is nowhere better exemplified than in the comparatively recent growth of the art, the science, or the profession (according to the point of view) of City Planning. Up to the present time very few cities have been scientifically laid out at the beginning, and hardly any have exercized any systematic care toward their subsequent growth. The result is well shown in Boston, where at this time the general public, the city government, the various transportation organizations, and the suburban population are trying to agree on some plan for a new subway,

which shall be agreeable to all, and shall interfere as little as possible with the complicated and ramified systems already in operation.

Some intelligent forethought toward the future growth of a city, and some definite plan by which that growth may be systematically controlled, not only alleviates the difficulties of transportation incumbent upon an uncontrolled and often illogical growth, but presents strong inducements toward the maintenance of sanitation and health, and the general convenience and well-being of the public. City Planning not only endeavors to embrace all this (as is shown later), but also attempts to remedy existing defects in cities and towns already feeling the annoyances and difficulties of uncontrolled, wavering and unequal expansion.

The Department of Landscape Architecture is about to issue through the University Press a City Planning Classification Scheme, which will appear early in June. The Preliminary Outline of this classification is already issued, and from it is apparent the enormous development, and the broad scope, of City Planning.

"The term City Planning is used to signify 'the intelligent control and guidance of the physical conformation, growth, and alteration of cities, towns, or considerable parts thereof, considered in their entirety.'"

Some idea of the wide range of topics covered by the Classification may be conceived when it is remarked that the Outline alone covers six and one-half large pages. The subjects covered vary from the bibliography, history, and legislation of the subject, to the execution, study, and composition of city plans. Under the latter come considerations not only of the larger details of the proposed plans, but such related questions as those of transportation, streets, railroads, conduits, wires, land subdivision, open spaces, structures (buildings, dams, viaducts), and a thorough discussion of the various types of city plans dependent upon climate, population, topography, commerce, etc.

The value of the forthcoming scheme is enhanced by "the fact that it is developed in accordance with the principles of and capable of insertion in, the Library of Congress Classification." This City Planning Classification Scheme, containing a

subject-index, and provided with numbers for use in classifying material, may be purchased when issued from the Harvard University Press.

"A recent dispatch from Nome, Alaska, announced the loss of the vessel which John E. Thayer, '85, sent to the Arctic and sub-Arctic regions to obtain zoölogical, botanical, and natural history specimens for the University, and for Mr. Thayer's private museum. Captain John Koren, who was in charge of the expedition, sent word, however, that the material secured in the trip had been saved, and was stored in Siberia.

"The vessel left Tacoma, Wash., April 26, 1910, manned by Captain Koren, and three other white men, who were later reinforced by two Esquimos. It had visited the islands off the coast of Alaska, the Behring Sea, and the Arctic Ocean."

Harvard Alumni Bulletin, April 9, 1913.

The JOURNAL takes great pleasure in announcing the election to the Board of Editors of C. G. Hill, 1G.S., of Chicago, Ill.; W. H. Capen, '13, of Newton; and F. C. Millspaugh, 1G.S., of Utica, N. Y.

ASSOCIATION OF HARVARD ENGINEERS

The annual dinner and meeting of the Association is to be held this year on Wednesday, June 18, at 6.30 P.M., in the Harvard Union. It is hoped that by holding this event in Commencement week, instead of in March, a very much larger number of graduates will be able to attend than has been the case in previous years.

An especial entertainment is promised in the illustrated addresses of Professor Kemp of Columbia, and Dr. Chuan of Pekin, China, who is now in the Harvard Medical School.

The Year Book of the Association, giving changes of address and occupation of the members, will be published the last of June.

HARVARD ENGINEERING SOCIETY OF NEW YORK

The regular meeting of the Harvard Engineering Society of New York was held at the Harvard Club, Saturday, May 3. An excursion had been planned for the afternoon to the plant of the Barber Asphalt Co., at Maurer, N. J., but owing to a strike at this plant it was decided to omit the excursion.

The regular business meeting was held at 8 o'clock, at the close of which Mr. Clifford Richardson, Consulting Engineer and member of our Society, gave a very interesting paper on asphalt, which was illustrated by stereopticon views.

The annual meeting of the Society will be held Saturday, June 7, at the grounds of the New York Athletic Club, at Travers Island, N. Y. The day will be given over to baseball, tennis, swimming and boating. Following the field sports, dinner will be held at the Club House, and there will be an election of officers for the year 1913-1914. The following list of nominations for officers has been submitted by the Committee on Nominations:

J. R. Finlay, '91, President.
Thomas Crimmins, '00, Vice-President.
Charles Gilman, '04, Secretary.
C. M. Holland, '06, Treasurer.

Executive Committee.

John R. MacArthur, Francis Mason, Arthur C. Jackson (Past Presidents).

Clifford Richardson, '77.
Sidney J. Jennings, '85.
Warren Delano, '74.
John R. Healy, '97.
Ralph R. Rumery, '99.
Roger C. Barnard, '02.
Dean G. Edwards, '03.

Advisory Committee.

George S. Rice, '70 (Past President).
Franklin Remington, '97 (Past President).
B. B. Thayer, '85 (Past President).
H. M. Hale, '04 (Past Secretary).

CHARLES GILMAN, *Secretary.*

HARVARD ENGINEERING SOCIETY

The papers presented before the society at the last four meetings were as follows: "Terrestial Magnetism; Its Investigation and Practical Value," by Mr. Lloyd W. Weed; "Quicksand," by Mr. George H. Hazlehurst; "The Control of Electric Motors," by Mr. B. W. David and Mr. A. A. Prior; and "The Development of the Electric Railway," by Mr. F. D. Everett.

Mr. Weed spoke on the evening of March 7 in the Common Room of Conant Hall. He gave a very interesting description of the early discovery of loadstone, and the resulting discovery of the magnetic properties of the earth. At the present time the United States Government maintains several fully equipped magnetic observatories, and is making a systematic study of the earth's magnetism and its changes. The speaker, who was engaged in this work for two years, described the equipment of these observatories and the niceties of adjustment and precautions which must be used. A number of maps and lantern slides were used to explain various points.

The next meeting, which was addressed by Mr. Hazlehurst, was held on Friday evening, April 4, in Conant Hall. The speaker introduced his subject by alluding to the old-time superstitious dread and fear commonly associated with the word "quicksand." In its composition it is as simple as its actions are treacherous. Certain kinds of fine sands saturated with water become "quick" when agitated or disturbed, and in this way often lead to great expense and trouble in engineering construction. Pipe lines are often completely filled by this fine sand working in through joints, and being precipitated as a very hard and compact sediment. A number of incidents were related from the speaker's experience with the quicksand problem, which illustrated the extreme measures sometimes made necessary by this evil, the bugbear of the contractor.

A number of little bottles containing certified "live" specimens were exhibited and were examined with unusual interest by those present.

The meeting on the evening of April 25 was held in Pierce Hall in order to make use of the reflectoscope and have at hand a little "d. c." for demonstration purposes. The subject was

"The Control of Electric Motors," and was divided into the fields of direct and alternating currents. The general method of treatment in each was a brief description of the types of motors considered, various kinds of control necessary, the theory of speed control, the practical methods of control, as hand-operated, automatic and semi-automatic, and various other usual and unusual schemes and devices. A number of control devices were exhibited, explained and operated. A wide variety of control devices were shown by projecting on the screen illustrations from manufacturers' catalogs.

On Friday evening, May 16, Mr. F. D. Everett spoke on "The Development of the Electric Railway."

The annual meeting of the Society, the final meeting of the year, was held May 23. The following officers for the year 1913-1914 were unanimously elected: President, C. H. Marsh, 1G.S.; Secretary, E. L. Robinson, 2G.S.; Treasurer, L. W. Weed, 1G.S. The following resolution was passed:—

"WHEREAS, Ira Nelson Hollis, Professor of Engineering, is to leave Harvard University to accept the position of great honor and trust conferred upon him by the Worcester Polytechnic Institute, and

"WHEREAS, Professor Hollis has always been a staunch and earnest friend of this Society, be it

"RESOLVED: that the Harvard Engineering Society wishes at this time to express deep gratitude to Professor Hollis for his sacrifices to Harvard University, and to this Society, and to extend the most sincere hope that success may attend all his efforts in his new position, and that he may enjoy ever increasing opportunity for service to the cause of technical education and to the engineering profession; and be it furthermore

"RESOLVED: that these resolutions be spread upon the record of the Society, that a copy be delivered to Professor Hollis, and that they be printed in the HARVARD ENGINEERING JOURNAL."

Following the business meeting, Professor A. E. Kennelly gave a very interesting illustrated lecture on his personal experiences in laying submarine cables.

B. W. DAVID, *Secretary.*

WIRELESS SOCIETIES

Harvard Wireless Club

The annual meeting and election of officers of the Harvard Wireless Club was held May 6. The officers elected for the ensuing year are: President, Dr. G. W. Pierce; Manager, E. T. Drake, Jr., '16; Secretary-Treasurer, E. B. Dallin, '16; Member of Executive Committee, W. H. Capen, 1G.S.

During the past year about twenty-five members of the club have taken the course on Wireless Telegraphy given by the officers and members at the fortnightly meetings. Several men prominent in the profession also spoke before the Club. The Club has had the use of the aerial on Matthews for the first time, and early in the year the Club apparatus was placed in operation in the club-room, Grays 13. About seventy dollars' worth of apparatus is now in the possession of the Club, much of it added this year through the kindness of the manufacturers near the city of Boston. The library on Wireless Telegraphy owned by the Club was largely increased during the year, and is now at the disposal of members in the well-furnished club-room. With such equipment and with the full apparatus of a wireless station the prospects of a very successful future are assured.

E. T. Drake, *Manager.*

New England Wireless Society

The fourth meeting this season of the New England Wireless Society was held April 5, in Room 202, Pierce Hall. Nominations were made for officers and executive committee to be elected at the next meeting.

Profssor A. E. Kennelly was the speaker this evening. With introductory remarks on the similarity of free waves and those guided by wires, he developed a lucid explanation of the nature of the Hertzian wave. His main subject was the daylight effect and a discussion of meteorological conditions as affecting radio-telegraphy. The talk was illustrated by lantern slides.

The last meeting of the year will be held June 7 at Technology. The speaker will be Mr. John L. Hogan, Jr., of the National Electric Signaling Company, who will describe the

heterodyne receiver lately developed by that company. As this detector is the most modern device of the kind, and as Mr. Hogan has been closely concerned in the experimental work connected with its perfecting, the address should prove of unusual interest. Harvard men are cordially invited to be present.

E. W. CHAPIN, *Secretary.*

GRADUATE NOTES

(On account of the many inquiries as to the whereabouts of the graduates of the department, it is hoped that the Graduate Secretary will be notified of changes of address and occupation, etc. Such notes will appear promptly under this heading.)

HENRY M. HOWE, '69, Senior Professor of Metallurgy at Columbia University, will retire from active service on June 30, 1913, with the title of Professor Emeritus.

SAMUEL HILL, '79, is President of the Home Telephone and Telegraph Company of Portland, Ore.

FREDERICK A. DELANO, '85, was a member of the Peace Conference in St. Louis, May 1 to 3.

GUY LOWELL, '92, has been selected as the architect for the new courthouse in New York City. Mr. Lowell's Boston office is at 12 West Street, and his New York office is at 225 Fifth Avenue.

C. J. TILDEN, '96, Assoc. M. Am. Soc. C.E., Consulting Engineer, and Professor of Engineering Mechanics at the University of Michigan, has resigned to become Professor and head of the new department of civil engineering at Johns Hopkins University, Baltimore. Professor Tilden, after graduating from Harvard, was for several years structural draughtsman and assistant engineer with the New York City Rapid Transit Commission. He was appointed Instructor in Civil Engineering at Cornell University in 1904, and the following year went to the University of Michigan as Professor of Civil Engineering.

Owen B. Huntsman, '97, Vice-President of the Missouri Pacific Railroad, has been elected a Director of the Texas and Pacific Railway Company.

Horace F. Lunt, '98, mining engineer, of Colorado Springs, Colo., is just now engaged at the Hillabee Gold Mine, Alexander City, Ala.

Thomas Nickerson, '99, formerly of Haverhill, Mass., is now with the General Electric Company, 609 Coleman Building, Seattle, Wash.

Hugo Parton, '01, is Advertising Manager for Gray & Davis, Inc., manufacturers of lamps, dynamos and starting motors for automobiles, Landsdowne Street, Boston. His home address remains Newburyport, Mass.

Arthur L. Sweetser, '01, has been practising mining engineering since leaving college. We quote from a card from him from Ocos, Guatemala: "Experience, two years studying and teaching, ten years' practical experience in the United States, Mexico, Canada, Honduras, and Guatemala. Member American Institute Mining Engineers past seven years, also Los Angeles Chamber of Mines. Contributor of articles to the various technical journals." His address is P.O. Box 27, Boston.

Stanley B. Weld, '01, is Assayer with the New York and Honduras Rosario Mining Company, at San Juancito, Honduras.

Aldrich Durant, '02, is in the Havana office of MacArthur, Perks & Company, general contractors. His Havana address is San Francisco Pier.

K. E. Adams, '02, has taken a position with the Edison Illuminating Company of Boston, as head of the incandescent lamp division. His home address remains 1019 Washington Street, Newtonville, Mass.

Herbert M. Boylston, '03, formerly Instructor in Metallurgy and Metallography at Harvard, is now associated with Professor Sauveur as consulting metallurgical engineer at the Abbot Building, Cambridge. Mr. Boylston has recently been appointed sec-

retary of the executive committee of the iron and steel division of the American Institute of Mining Engineers, of which committee Professor Sauveur is vice-chairman.

A. D. Wilt, Jr., '03, is President of the Wilt Twist Drill Company, Ltd., of Walkerville, Ont., and also Vice-President and General Manager of the Schweppe and Wilt Manufacturing Company, makers of automobile parts, of Detroit, Mich. Mr. Wilt has invented a machine which produces automatically, in one operation, a drill, the making of which used to require six machine and two hand operations.

Professor Manton Copeland, '04, of the biological department of Bowdoin College, will be one of a small party of scientists who will go this summer with the Crocker land expedition to Greenland for scientific research.

A daughter was born to Wallace St. C. Jones, '05, in Cambridge, on February 17.

Osgood Batchelder, '05, is with the General Electric Company, Minneapolis.

G. D. Scholl, '05, started May 28 from San Francisco for Australia, to take a position as Assistant Superintendent of the Electrolytic Refining and Smelting Company of Australia, Ltd., situated at Port Kembla, New South Wales.

Tennyson W. Sampson, '05, who is with the Western Electric Company, Purchase Street, Boston, has moved from Whitman to 236 Third Street, Lowell, Mass.

Charles B. Hibbard, '06, is with the American Locomotive Company, Providence, R. I. His home address is "The Minden," Waterman Street, Providence.

Oliver D. Filley, '06, is now at Bulawayo, Rhodesia, South Africa, in the employ of the British South Africa Company's Mine Development Company.

Kenneth W. Lamson, '06, is Instructor in Mathematics at the University of South Dakota, Vermillion, S. D.

Harold W. Nichols, '07, Vice-President and General Manager of the Fox Paper Company, Cincinnati, has been elected

President and General Manager of a new Virginia corporation, the Chesapeake Pulp and Paper Company, Inc. The treasurer is Melville T. Nichols, '01, of Nichols and Drown Company, Lynn, Mass.

GORTON JAMES, '08, who has been in Boston since 1910 as secretary to Mr. T. E. Byrnes, Vice-President of the New York, New Haven and Hartford Railroad, has been transferred to New York City to take charge of Mr. Byrnes' office at the Grand Central Terminal, Room 5054. His home address is Rye, N. Y.

LYFORD ROME, '08, is President of The Rome Corporation Builders, 105 West 40th Street, New York City. He has specialized in building since leaving college and has worked on about forty buildings, ranging from suburban residences to the new Woolworth Building.

C. MASON FARNHAM, '08, has been appointed Instructor in Geology at Lehigh University, South Bethlehem, Pa.

CLAIBORNE M. GARRETT, '10, is with the Carnegie Steel Company, Third National Bank Building, St. Louis, Mo.

IVAN A. BLAKE, '10, is in the drafting department of the Gamewell Fire Alarm Company, Boston.

H. MALCOLM PIRNIE, '10, who has been in the Ottawa office of Hazen & Whipple, is now at their New York office at 103 Park Avenue.

PAUL A. MERRIAM, '10, M. M. E. '12, is in the engineering staff of Grisom-Russell Co., New York City. He has been with the Wheeler Condenser & Engineering Company of Carteret, N. J., since leaving Harvard.

WARREN B. STRONG, '10, former Editor-in-Chief of the JOURNAL spent the last nine months in a tour around the world. He writes that his occupation is now "finance," and that his permanent address is 651 Fairmount Avenue, Saint Paul, Minn.

CHARLES D. BURRAGE, JR., '11, who has been with the Stone & Webster Company at Key West, Fla., has been transferred to the accounting department of the same concern at Baton Rouge, La. His address is care of the Baton Rouge Electric Company.

George S. Squibb, '11, who has been with Stone & Webster, Boston, since his graduation, has resigned to enter the firm of the Andrew G. Paul Company, heating and drying specialists, 131 State Street, Boston.

Calvin D. Crawford, '11, was recently married in Cotuit, Mass., to Miss Mita Morse.

Earle R. Kimball, '11, formerly with the Packard Motor Company of Philadelphia, is with the Boston Envelope Company, 185 Franklin Street, Boston. His home address is 296 Boston Avenue, Tufts College, Mass.

Charles Thurlow, Jr., '12, who was with Stone and Webster, is now with the Pensacola Electric Company, Pensacola, Fla.

E. Tyler Davis, '12, is Secretary of The Tyler Tube and Pipe Company, Washington, Pa.

Robert T. Paessler, '12, is an analytical and consulting chemist, with an office at 708 Coal Exchange Building, Wilkes-barre, Pa.

Lewis J. Catheron, '12, who has been with Stone and Webster since his graduation, has been transferred from the Boston office to the accounting department of the Northern Texas Traction Company, Fort Worth, Texas.

Norman Davenport, '12, is with the Turners Falls Company, Turners Falls, Mass.

Joseph H. Perry, Jr., '12, is with the Pennsylvania Railroad. He is at present a member of the engineering corps of the Pittsburgh, Cincinnati, Chicago and St. Louis Railway, Pittsburgh Division, 1013 Penn Avenue, Pittsburgh. His address is 3014 Bergman Street, Sheridanville, Pa.

Holger W. Clausen, '12, formerly civil engineer with the U. S. Reclamation Service in Montana, is with the Turners Falls Company, Turners Falls, Mass.

Robert H. Burrage, '13, is in the engineering office of the Chino Copper Company, Santa Rita, New Mexico.

B. W. David, 2G.S., spent ten days, at the time of the April recess, in Edgewater, N. J., making a series of tests on the electrical equipment of the Warner Sugar Refinery.

PERSONAL NOTES

PROFESSOR A. E. KENNELLY delivered lectures on "The Daylight Effect in Wireless Telegraphy" to the Pittsfield Section of the A. I. E. E. (March 13), to the Lynn Section (March 26), to the New England Wireless Association (April 5), and to the Institute of Radio Engineers, in New York (May 8).

PROFESSOR E. V. HUNTINGTON presented a paper entitled "Sets of Independent Postulates for Betweenness (second paper)" at a meeting of the American Mathematical Society in New York, on April 26.

PROFESSOR G. W. PIERCE delivered three lectures on Wireless Telegraphy to the student officers of the Post-Graduate School of the U. S. Naval Academy at Annapolis, May 7 to 9.

At a meeting of the Board of Directors of the Seismological Society of America, held in Berkeley, Cal., April 10, Professor J. B. Woodworth was elected Third Vice-President of the Society.

PROFESSOR ALBERT SAUVEUR has been appointed expert examiner by the United States Civil Service Commission.

PROFESSOR A. E. KENNELLY has been appointed an Honorary Corresponding Member by the British Association for the Advancement of Science.

PROFESSOR G. W. PIERCE lectured on "The Wireless Telephone" before the Inventors' Guild in New York, on March 28, and before the Franklin Institute, Philadelphia, April 16. At Philadelphia, on April 19, he took part in the Symposium on Wireless Telegraphy held by the American Philosophical Society. His subject was "Resonance in Radiotelegraphic Receiving Stations."

At the meeting of the American Physical Society, held at Washington, D. C., April 25 and 26, the following papers were contributed by members of the Division of Physics of Harvard University: "Preliminary Report on Throttling Experiments with Superheated Steam," Mr. Howard M. Trueblood; "Note on the Value of Throttling Experiments as a Basis for Computing Steam

Tables," Professor Harvey N. Davis; "The Electric Spark.—Spectrum of the Spark," Mr. William O. Sawtelle; "The Spectrum of Mercury in the Schumann Region," Professor Theodore Lyman; "On the Maximum Value of the Magnetization Vector in Iron," Professor B. Osgood Peirce.

A course of some twenty lectures on "Geology of Fuels," open to members of the University, was given the latter part of the term by Professor Graton of the Geological Department. Professor Jaffrey, of the Department of Botany, devoted several lecture periods to outlining results of his investigations upon the microscopic structure of coal, and the bearing of this upon the composition, properties, and uses of coal.

The first series of the Cutter Lectures for 1912-13 was given at the Harvard Medical School by Professor G. C. Whipple, as follows: March 31, "The Use of Vital Statistics with Truth"; April 2, "With Imagination"; April 7, "With Power." These lectures are given annually under the terms of a bequest from John Clarence Cutter, whose will provided that the lectures so given should be styled the "Cutter Lectures on Preventive Medicine," and that they should be delivered in Boston, and be free to the Medical Profession and the Press.

Professor Albert Sauveur and H. M. Boylston are associated as consulting metallurgical engineers at the Abbot Building, Harvard Square. Mr. Boylston has been appointed secretary to the Executive Committee (of which Professor Sauveur is Vice-Chairman) of the Iron and Steel Division of the American Institute of Mining Engineers.

Professor Bruce Wyman, '96, of the Harvard Law School, who gives a course on Contracts and Specifications in the School of Engineering, has been appointed counsel for the New England Railroad Lines in matters affecting interstate commerce.

Recent Publications by Harvard Men and by the Staff.

"A Laboratory Manual for Physical and Commercial Geography." Ralph S. Tarr, '91 (with O. D. von Engeln). Macmillan.

"Practical Physics for Secondary Schools." Newton Henry Black, '96 (with Professor Harvey N. Davis). Macmillan.

"Handbook of English for Engineers." Wilbur O. Shepherd, Ph.D., '06. Scott, Foresman.

"Sanitary Protection of the Water Supplies taken from the Great Lakes." Professor G. C. Whipple.

"A Simple Formula for Computing the Gyroscopic Forces in an Aeroplane." Professor E. V. Huntington. *Science,* March, 1913.

"Statical Limitations upon the Steel Requirement in Reinforced Concrete Flat Slab Floors." John R. Nichols, '06. *Proc. Am. Soc. C. E.,* April, 1913. (presented before the Society, May 21).

Books Added to the Engineering Library

Electrical Engineering

Aitken.—Manual of the Telephone.
Bohle.—Electrical Photometry and Illumination.
Crook.—High Frequency Currents.
Haller and Cunningham.—Tesla High Frequency Coil.
Hobart.—Design of Polyphase Generators.
Horstman and Towsley.—Practical Armature and Magnet Winding.
Northrup.—Methods of Measuring Electrical Resistance.
Trotter.—Illumination.

Civil Engineering

Adams.—Theory and Practice of Designing.
Adams.—Sewerage of Sea-coast Towns.
American Railway Master Mechanics' Association—Locomotive Dictionary.
Barnes.—Ice Formation.
Bishop.—Structural Details of Hip and Railway Rafters.
Crandall and Barnes.—Railroad Construction.
Croker.—Fire Prevention.
Cullmer.—Elevator Shaft Construction.
Dartein.—Ponts Français.
Faber and Bowie.—Reinforced Concrete Design.

FREITAG.—Fire Prevention and Fire Protection.
GREINER.—General Specifications for Bridges.
McKIBBEN.—Hip and Valley Design.
Master Car-builders' Association.—Car-builders' Dictionary.
PAGE.—Roads, Paths, and Bridges.
PRATT.—Materials and Construction.
RICKER.—Treatise on the Design and Construction of Roofs.
SLOCUM and HANCOCK.—Strength of Materials.
TYRELL.—Engineering of Shops and Factories.
WITHEY.—Laboratory Notes on the Strength of Materials.

Mechanical Engineering

ABADY.—Gas Analyst's Manual.
ANGUS.—Theory of Machines.
BURSTALL.—Energy Diagram for Gas.
DUCHESNE.—Recherches sur les Propriétés de la Vapeur d'eau Surchaufée.
HAEDER.—Ölmoteren.
HATFIELD.—Cast Iron.
HAVARD.—Refractories and Furnaces.
HOBART.—Millwrighting.
HORNBY.—Gas Engineer's Laboratory Handbook.
JAUCH ET MASMÉJEAN.—Machines Alternatives.
JEANS.—Mechanics.
JOSLYN.—Energy and Velocity Diagrams of Large Gas Engines.
LAKE.—Composition and Heat Treatment of Steel.
MACFARLANE.—Iron and Steel Manufacture.
MARCHIS.—La Vapeur d'eau Surchaufée.
MARTIN.—Design and Construction of Steam Turbines.
MORGAN.—Notes on Foundry Practice.
PAGÉ.—Modern Gasoline Automobile.
PFANSTIEHL.—Ignition.
RIPPER.—Steam Engine Theory and Practice.
SANBORN.—Mechanics.
SAUVAGE.—Lectures on Superheating in Continental Locomotives.
SEXTON.—Fuels and Refractory Materials.
SHEALY.—Steam Boilers.
WOODWARD.—Rational and Applied Mechanics.

Miscellaneous

BLESSING and DARLING.—Descriptive Geometry.
CATHCART and CHAFFEE.—A Short Course in Graphic Statics.
FRIEND.—Corrosion of Iron and Steel.
MACOMBER.—Engineers' Handbook on Patents.
MARTIN.—Mechanics, Vol. IV.
PALMER.—Practical Mathematics.
PRINDLE.—Patents in Manufacturing.
SCHAFF.—Essential Points on the Value of Engineering Property.
WATSON.—British Weights and Measures.
WILLISTON.—Cases on Engineering Contracts (Arranged by Wyman).

SUMMER COURSE IN MUNICIPAL SANITATION.

During the summer of 1913 the University will offer the following group of courses relating to the general subject of municipal hygiene and sanitation. They are arranged with special reference to those who are teaching these subjects in other institutions and who would like to obtain a practical demonstration of the principles of sanitation applied to actual problems. The courses should also prove valuable to students of civil engineering, sanitary engineering, municipal government and sociology, as well as to public health officers who are able to secure a short leave of absence from service.

The work will begin on June 30, and will close August 9, 1913, covering six weeks of lectures, laboratory work and field work. The tuition fee for the course is $30.00. The laboratory fee is $10.00.

These courses will cover substantially the same ground as the general course in Sanitary Engineering (9K) given in the Harvard School of Engineering and will be accepted as its equivalent by candidates for the degree of Master in Civil Engineering in the Harvard School of Engineering.

Particular attention is called to the unique opportunities for the practical application of the principles taught in the laboratory to sanitary works in the vicinity of Boston described under Part D.

Persons desiring to take these courses should write to Professor George C. Whipple, Pierce Hall, Harvard University, Cambridge, Mass., before June 15, 1913, stating their qualifications for undertaking the work.

PART A.

Municipal Sanitation.

Thirty-six lectures on Mondays, Tuesdays and Wednesdays (two each day), by Professor Whipple. Among the topics to be considered are the relations to municipal sanitation of water supply, sewage and garbage disposal, and ventilation. The lectures will be given in Pierce Hall at 9 A. M., and at 2 P. M.

PART B.

Vital Statistics.

Twelve lectures on *Thursdays and Fridays,* by Professor Whipple and Mr. Schattschneider. The lectures will be given in Pierce Hall, at 8 A. M. (The early hour is chosen in order that the time after 10 A. M. may be devoted to field work.)

PART C.

Sanitary Biology.

Twelve lectures on *Thursdays and Fridays,* by Dr. Bunker. The lectures will be held at Pierce Hall at 9 A. M.

PART D

Field Studies in Applied Sanitation

This course will consist of a series of field excursions to various places of sanitary interest in the vicinity of Boston for purposes of practical work, and of a series of exercises in the sanitary engineering laboratory at Pierce Hall. This laboratory is fully equipped for making physical, chemical, and biological examinations of water and sewage. The laboratory work will

demand about fifteen hours per week, and about ten field trips for work and five for inspection will be made during the course. The work taken up in the laboratory will cover the most important elements of water and sewage analysis given in the report of the committee on Standard Methods of Water Analysis of the American Public Health Association. The principal object of the field excursions is to demonstrate the practical application of these methods. Among the places that will be visited are the following:—Boston Harbor, Charles River Basin, Cambridge Water Works, Merrimac River, Lawrence, Worcester, Springfield, Brockton, Providence, and the Metropolitan Water Works Reservoirs.

NOTICES

The instructors and students of the Sanitary Engineering Department have been making a study of the sanitary quality of the Cambridge water supply. A sanitary survey of the watershed is in progress and special studies are being made at Fresh Pond. This work is a part of the policy of coöperation now existing between the University and the city of Cambridge. Professor Hughes and Professor Whipple recently inspected the watershed in company with the Mayor and the Cambridge Water Board.

The pamphlet of the School of Engineering for the year 1913-14 was issued April 26, and may be obtained at the Publication Office.

The School of Engineering has this year started a collection of the photographs of its members. This excellent custom has been followed in the Law School for many years.

The National Acme Manufacturing Company gave a demonstration of one of their automatic multiple spindle lathes in Pierce Hall, May 6 to 8.

Receipt is acknowledged of reports on the United Railways Company of St. Louis by the St. Louis Public Service Commission, of which James E. Allison, '87, is Chief Engineer.

The order of the Final Examinations in the School of Engineering is as follows:—

Saturday, June 7: Engineering 11L.
Monday, June 9: Engineering 12K.
Tuesday, June 10: Engineering 16l.
Wednesday, June 11: Engineering 7L, Physics 4a.
Thursday, June 12: Engineering 2L, Engineering 7M, Engineering E17L.
Friday, June 13: Engineering 16P, Engineering 4N.
Saturday, June 14: Engineering 9K, Engineering E17M.

BOOK REVIEWS

RAILWAY ROUTES IN ALASKA

Report of the Alaska Railroad Commission

This report is an extensive examination into the transportation question of the Territory of Alaska by the committee appointed by the President. Alfred H. Brooks, L.S.S., '94, was a member of the Commission, and the excellent descriptions of the mineral resources of Alaska are due to him.

The report contains two colored maps of Alaska and five charts of the important harbors. The climate, Resources, Population and Commerce of Alaska in general are first described. A detailed report on the several possible railway routes is then presented, giving descriptions of the line followed and the resources and characteristics of the country through which it passes. A comparison of the various harbors, their capability of development, and their relative value as termini follows.

Finally, in an analysis of construction costs, the Commission recommends the construction of a railroad from Chitina to Fairbanks which should either be built by the Government, or the construction costs of which should be guaranteed by it. The cost of construction is estimated as $13,971,000, the road to be 313 miles in length, with a charge of 6 cents per mile passenger fare, and 5.49 cents per ton-mile freight rate. In appendices are a list of Panama Canal machinery available for construction work, statistics of commerce and industries, and notes on Canadian Railway work. Perhaps not the least valuable part of the report is the extensive bibliography of the various publications on the subject.

The report as a whole is comprehensive and presents much valuable information upon a subject which is just now coming to be of national importance.

ANALYTICAL MECHANICS FOR STUDENTS OF PHYSICS AND ENGINEERING

By Haroutune M. Dadourian

(*Instructor of Physics in the Sheffield Scientific School of Yale University. Published by D. Van Nostrand Co. Price,* $3.00.)

In reviewing a book on so familiar a subject as mechanics, the reviewer naturally looks first to see whether there is any single striking feature of the book by which it can be readily differentiated from all other books in its class.

In the book before us there is such a characteristic feature, namely, a new point of view in regard to the fundamental laws on which the whole development of the subject is based. Instead of the usual "Newton's Three Laws of Motion," the author prefers a single fundamental law, which he states as follows:

"To every action there is an equal and opposite reaction; or the sum of all the actions to which a body is subject at any instant vanishes."

On the face of it, this law is certainly not lacking in simplicity; but on reading further it appears that the word "action" is made to do duty for no less than four different concepts, namely, "force," "torque," "linear kinetic reaction" and "angular kinetic reaction." In the practical application of the principle to the motion of a particle, the 'sum of all the actions" to which the body is subject becomes: "the sum of all the impressed forces *plus* the linear kinetic reaction"; and again, in applying the principle to problems of rotation of a rigid body, the "sum of all the actions" becomes "the sum of all the torques *plus* the angular kinetic reaction."

It thus appears that the "linear kinetic reaction" is equivalent to the usual *ma,* or rather, to —*ma,* while the "angular kinetic reaction" is equivalent to $-I\frac{d\omega}{dt}$. The simplification secured by substituting one law for three is therefore more apparent than real. In the opinion of the present reviewer, nothing whatever is gained by the innovation.

The author's attempt to base his theory on Newton's Third Law of Motion (p. 15) is particularly unfortunate, since the Third Law of Motion expressly concerns the relation that exists be-

tween *two distinct bodies,* while the author's paraphrase of it is made to cover the relation which exists between a *single* body and an impressed force. When Newton spoke of "action and reaction," he certainly never dreamed of regarding an impressed force as an "action" and the inertia of the body as the "reaction"; and yet this seems to be essentially what our author's theory amounts to.

This very serious misinterpretation of Newton's Third Law of Motion is altogether too common in recent text-books. For example, in Slocum's Theory and Practice of Mechanics, 1913, we find the explicit assertion that in the equation $F=ma$, "F is the 'action,' or tendency to produce motion, and ma is the 'reaction,' or inertia force set up." It is doubtful whether any other one thing has introduced more confusion into dynamical theory than this useless fiction of the "force of inertia."

In other respects, Dr. Dadourian's book has much to commend it. The topics are well chosen, and the problems good. The book is well printed, and the figures, while perhaps a little too black, are large and clear. An appendix contains a good collection of mathematical formulæ.

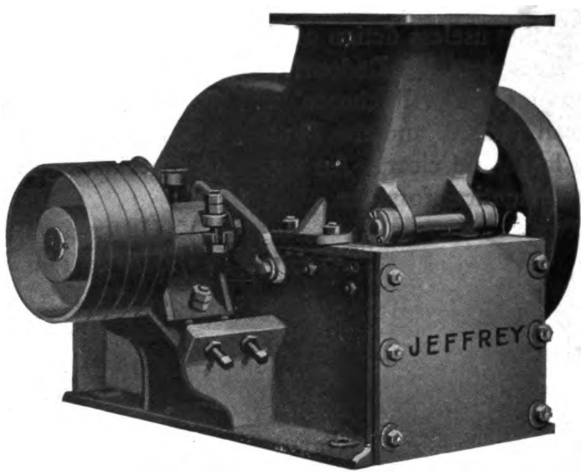
E. V. Huntington,
Assistant Professor of Mathematics.

TRADE NOTE

JEFFREY SWING HAMMER PULVERIZER

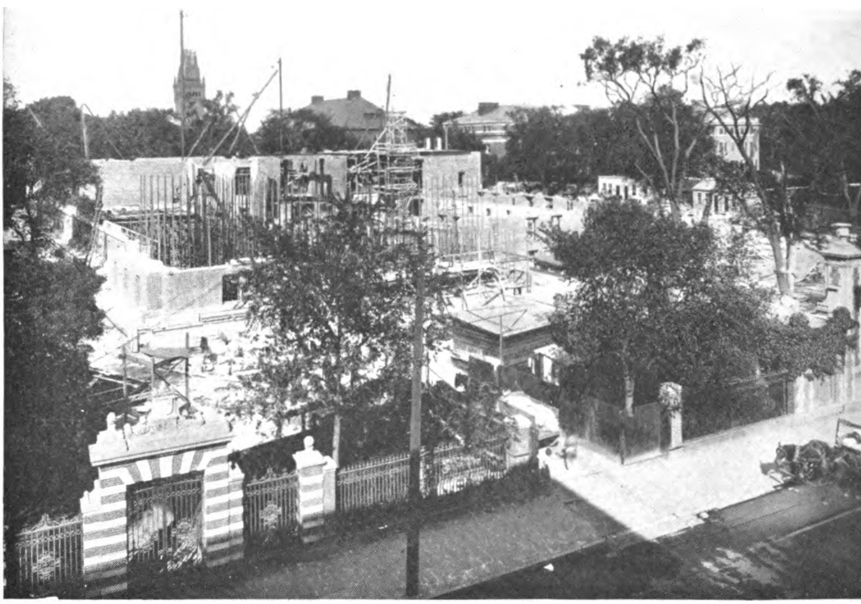
For Laboratory Use

This machine is built especially for laboratory use in reducing many materials to a fine uniform product for various purposes. It is especially useful in sampling coal and various ores, as it not only reduces the sample to a comparatively fine powder, but thoroughly mixes it into one homogeneous mass. It also has a place in many industries where a heavy duty or large capacity is not required.



While any high speed machinery is better for being placed on a solid concrete foundation, yet this machine is so well built that it gives very good service when mounted on timbers on an ordinary wood floor, as would be necessary in placing same on one of the upper floors of a factory building.

A very fine laboratory outfit consists of a pulverizer directly connected to an electric motor. Both are mounted on a single cast iron base and may be placed in any convenient position. The outfit is furnished complete, ready to run.



The Widener Library

HARVARD ENGINEERING JOURNAL

A QUARTERLY

Devoted to the interests of Engineering in Harvard University

THE OFFICIAL ORGAN OF THE ASSOCIATION OF HARVARD ENGINEERS

VOL. XII NOVEMBER, 1913 NO. 3

INSPECTION TRIP TAKEN BY THE STUDENTS IN SANITARY ENGINEERING

CLIFTON L. RICE, '12

In order that the students might see how the theories of the class room are put into actual practice, the members of the advanced course in Sanitary Engineering (C19d) at Harvard spent the week of May 19, 1913, inspecting various water works systems and filtration plants both of water and sewage, in the western part of Massachusetts and southern New York. The inspection trip was made by ten students under the direction of Professor George C. Whipple and Mr. Melville C. Whipple, and followed in all its essential parts the following tentative schedule:

SUNDAY, MAY 18

4.50 P.M. Leave South Station, Boston, on Boston & Albany R. R.

7.20 P.M. Arrive Springfield. Headquarters at Hotel Worthy.

MONDAY, MAY 19

8.00 A.M. or earlier. Leave by automobile for West Parish. Inspect slow sand filters, intake reservoir, and Borden Brook Reservoir. Return to Springfield. If time allows inspect air washer and swimming pool at Y. M. C. A. College.

7.25 P.M. Boston & Albany train to Albany.

10.40 P.M. Arrive Albany. Headquarters at Keeler's Hotel.

TUESDAY, MAY 20

8.00 A.M. Trolley to Albany slow sand filters. If time allows, proceed to Cohoes, N. Y., to inspect mechanical filters. Return to Albany.

5.25 P.M. West Shore R. R. train to Kingston, arriving 7.30, or

5.00 P.M. New York Central train to Rhinecliff, arriving 6.16. Ferry to Kingston. Kingston headquarters at Hotel Stuyvesant.

WEDNESDAY, MAY 21

7.20 A.M. Train for Kingston on Ulster and Delaware R. R. to Ashokan Dam. Inspection of dam and other features of the New Catskill Water Supply for New York City.

5.45 P.M. West Shore R. R. from Kingston, arriving Foot 42d Street, 8.30 P.M., or

6.16 P.M. New York Central R. R. from Rhinecliff, arriving Grand Central, New York City, 8.45 P.M. Headquarters in New York.

THURSDAY, MAY 22

9.00 A.M. Report at offices of Hazen & Whipple, 42d Street Building, corner 42d Street and Madison Avenue. (Entrance from subway at Grand Central Terminal.)

THURSDAY, MAY 22

10.00 A.M. Inspection of Bryant Park shaft of new water Supply Tunnel; followed by similar inspection at Highbridge.

P.M. Inspection Kensico Dam and Aeration on Croton Watershed.

FRIDAY, MAY 23

8.58 A.M. Leave Grand Central Station for Yonkers, arriving 9.33. Inspection slow sand filters and chlorination plant.

P.M. Inspection Sewage Works at Mt. Vernon. Trip to Dunwoodie Chlorination Plant on Croton Watershed. Trip to Coney Island in evening.

SATURDAY, MAY 24

9.10 A.M. Leave foot Chambers Street, Erie R. R., for mechanical filters at New Milford, N. J.

12.10 P.M. Return to Jersey City.

1.37 P.M. Leave Jersey City on Greenwood Lake Div. of Erie R. R. for Little Falls, N. J. Mechanical filters.

3.29 or 4.40 P.M. Return to New York.

This paper is an abstract of a report submitted to the school at the end of the trip, and aims to give a general outline of the trip, the plants visited, and some of the more noticeable features of the construction or operation of the individual plants. Free recourse has been made to current engineering periodicals, published reports, together with personal notes taken during the trip.

The party left Cambridge Sunday afternoon, and spent the evening in Springfield, making its headquarters at the Hotel Worthy.

SPRINGFIELD WATER WORKS

MONDAY, MAY 19

At 9 A.M. Monday morning we left the Hotel for an extensive tour of inspection of the watershed and filtration works of the Westfield Little River supply of the Springfield Water Works. This is a strictly gravity supply and, in brief, consists of a storage reservoir (2,500 M.g.* capacity) on Borden Brook, a tributary of the Westfield Little River, an intake dam in Cobble Mt. Gorge just below the junction of the Borden Brook and Westfield Little River, and a 4700 ft. tunnel through the mountain to the West Parish filters. Here there is a settling basin, in which the coagulant may be added, of 38 M. g. capacity, or approximately three days' supply, an aerator, and six slow sand filters of ½ acre each, operating at a rate of 6 M.g.a.d.† A laboratory building contains the coagulating apparatus, laboratory and turbines for generating the electricity for the plant. From the filters, a 42-in. steel lockbar pipe carries the water 7.4 miles to the Provin Mt. Reservoirs, of 17 M.g. capacity, and thence

* M. g., million gallons.
† M. g. a. d., million gallons per acre daily.

4.2 miles to the city, passing under the Connecticut River in two pipes. The plant is designed for 15 M.g.d., but really is capable of 18 to 20 M.g.d.

West Parish Filters

Through the courtesy of Mr. E. E. Lockbridge, Chief Engineer, two of the department automobiles were placed at our service. This, combined with the clear and bracing air, gave promise of a memorable trip. The first stop was at the West Parish filters. These are situated in a very beautiful spot, with

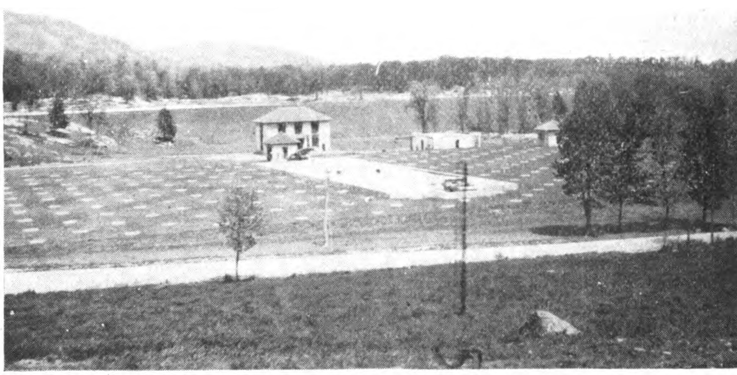


Fig. 1. West Parish Filters, Springfield, Mass., Water Supply

well wooded hills rising on three sides. That the structures in no way detract from the natural beauty of the place is evidenced by the accompanying picture. (Fig. 1.)

Upon alighting from the automobiles, we were at once struck with the evidences of good management. We saw closely cropped lawns over the filters, a well designed concrete laboratory building with a red tile roof, and several neat gate houses. All the structures were already partially covered with vines. Indeed it was more like a well kept country estate, than a plant for purifying water for Springfield's citizens.

We first inspected the laboratory building, which is two stories high. On the first floor there are two rooms, one in which a turbine generates the electricity needed about the plant by utilizing the 25-ft. fall between the sedimentation basin just back of the building, and the filters just in front; the other in which are the tanks and apparatus for feeding the coagulant into the raw water. The finely crushed alum, which is used here for a coagulant, is stored on the second floor and descends in a chute to the tanks below. The rate of feed is regulated by a small horizontal screw, motor driven. After being dissolved, the solution is pumped by a small centrifugal pump to the inlet end of the sedimentation basin. Above the turbine room on the second story are the office and laboratory. Here again, we were impressed with the splendid manner in which the plant was being run. Everything was on a strictly scientific and business-like basis. One noticeable feature was the absence of gas for maintaining the ovens and incubators at the desired temperatures. As there was no gas available in this region, use was made of the electricity generated below, and from appearances it would seem that it was cleaner and more flexible than gas. The bacteriologist showed us the records of the analyses of the raw and filtered waters, and the plates of the previous day's samples. All showed uniformly efficient results and proved that Springfield's water is pure from both the hygienic and esthetic standpoints. It has been found at this plant that it is better to apply double the required amount of alum for 12 hours and to rest 12 hours, than it is to dose continuously. Alum was not being used at the time we were there, and never is when the color is below 25. When the Borden Brook was first flooded, the color ran fairly high, but it has steadily decreased. The first year, ten carloads of alum were used; now, only two are required.

During the seven months of 1912, an average application of 4 p.p.m.* of aluminum sulphate reduced the color from 37 in the raw water to 15 in the filtered water. The success of this intermittent treatment is considered to be due to two facts;

* p.p.m., parts per million.

namely, that the raw water is very soft, having an average alkalinity of 10 p.p.m.; and that the sedimentation basin in which the treated and untreated waters mix is much larger than ordinarily found, having a capacity equal to three days' supply, which allow ample time for the discharge of the color.

It is a novelty to filter such a supply in America, although frequently done in Europe. The water is of such good quality that high rates can be used and thus only a moderate capital investment was required. ($300,000 in this case.)

After passing from the sedimentation basin, the water may

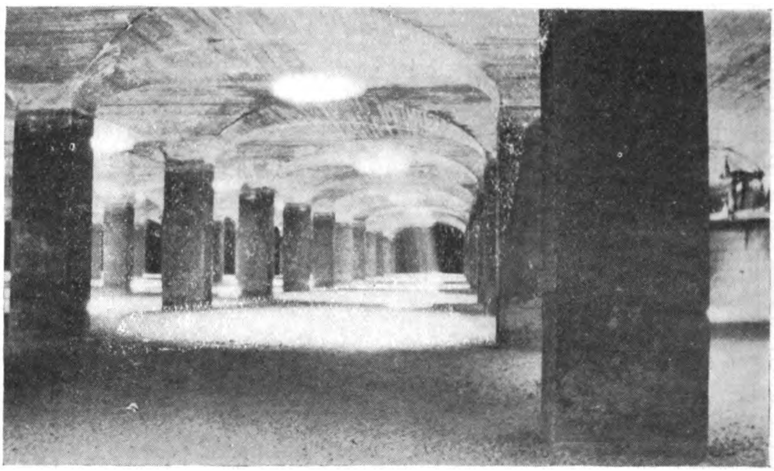


Fig. 2. Interior of Filter, West Parish Filters.

pass through the turbines to generate electricity for power, for supplying the wash water under pressure when cleaning the filters, or, if it is deficient in oxygen, it passes through the aerator directly in front of the laboratory building.

The aerator is seldom needed, but it was turned on for our especial benefit, and it was a splendid sight. A third variation for the flow is directly to the filters. Of course, any combination of these three may be used.

Mr. E. C. Cotton, the Superintendent in direct charge of the plant, had generously arranged to clean a filter bed while we

were there, and thus we were enabled to see the condition of the sand after being used. The interior of the filter before the sand was disturbed, is shown in Fig. 2.

Generally, the top ½ to ¾ in. of sand is shovelled into piles and then ejected to the sand court, where it is washed and returned hydraulically to the apparatus (Fig. 3) which separates the final wash water from the clean sand. This clean sand, containing less than 10% water, is drawn out at the bottom, and drops through a manhole upon a chute suspended from the roof of the filter.

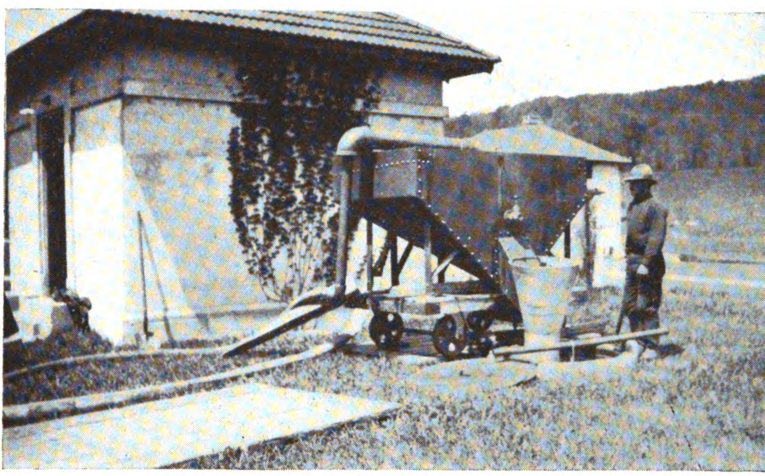


Fig. 3. Sand washing machine, West Parish Filters

This chute may be revolved, and thus the sand may be distributed over a wide area. When one section is finished, the chute is moved to another manhole. At the time of our visit, the filter was being given an extra cleaning, about four inches of sand being removed. An examination of the sand showed that, as usual, the upper layers did most of the work, as at a depth of 4 in. or 5 in. the discoloration of the sand was slight.

Returning to the top of the filters again, we went to the sand court where the sand removed from the filters was being washed. This apparatus was of the type so carefully worked

out at the Washington (D. C.) plant, very compact and accomplishing its purpose efficiently.

After viewing the sedimentation basin, which was formed by building a dike across a natural valley, we left West Parish and set out for the intake in Cobble Mt. Gorge, noting on the way the outlet of the tunnel under the ridge. This tunnel is 6 ft. 3 in. high and 5 ft. wide, with a capacity of 50 M.g.d. The grade was continually upward, and when skirting the crest of some of the hills we were afforded some truly magnificent views.

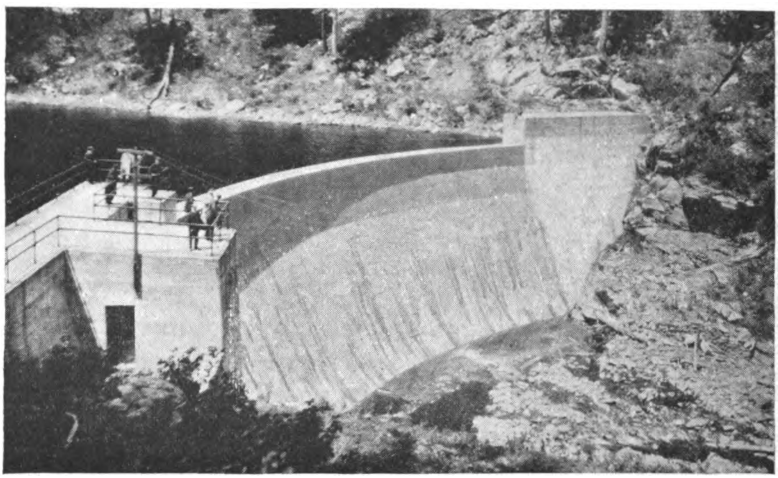


Fig. 4. Cobble Mt. Intake Dam

The entire watershed is ideal for supplying a city with good water, the population being less than thirteen per square mile.

Cobble Mt. Intake Dam

The site of the intake dam is in virgin, and till recently, inaccessible country. We left the automobiles on the summit of the ridge, and descended cautiously into the gorge, through which the stream has a fall of 100 ft. per mile. The city has just completed a winding path to the dam, and consequently the descent was not as bad as was feared on first sight.

By this time, the entire party was ready for lunch, and it was one of the many welcome events of the day. The accompanying photograph shows the dam, which is a well developed structure, being of the gravity-arch type. It holds back a pond of 52 M.g., of which 40 M.g. are available. The crest of the dam rises 50 ft. above the river bed, while the foundation is carred 28 ft. below it. The dam is 270 ft. long, 10 ft. thick on top, and 46 ft. thick at the bottom. The upstream face near the top is curved to prevent the possibility of extreme ice thrust, as the ice here has at times reached a thickness of 5 ft. In the abutment at the left of the picture are situated the gates controlling the flow to the tunnel and filters. The water may be taken at any level. There is also a measuring weir here to give accurate measurements of the dry weather flow. Such records are of value in the future development of the stream.

After lunch, we re-ascended the gorge. It was a different proposition from the previous descent, leaving us winded and very glad when we reached the automobiles and were moving still farther west to the Borden Brook Reservoir. The roads through this region, although not much used, are very good.

Borden Brook Reservoir

The natural flow of the Westfield Little River, which has a watershed of 48 square miles at point of diversion, is not sufficient for the demands of Springfield. Reservoir sites, however, are readily available, which when developed will yield 35 M.g.d. At present, only the Borden Brook tributary is developed by storage. The Borden Brook Reservoir has a drainage area of 8 square miles, and contains 2500 M.g., or 18 in. runoff from this area. This, added to the dry weather flow of the Westfield Little River, is more than sufficient to make available the 15 M.g.d. for which the present installation was designed.

We made but a short stay at the reservoir, merely riding around it and over the dam. The dam is of earth with a concrete core wall. It is claimed that this dam has never shown any signs of leakage. The entire property here showed that great care has been taken both in design and in management.

Provin Mt. Distributing Reservoirs

On the way back to the city we stopped at the pure water reservoirs at Provin Mt., an ideal site for distributing reservoirs. They maintain a pressure of 140 lbs. per sq. in. in the business section of Springfield, and 70 lbs. per sq. in. in the hill section, 130 ft. higher.

The reservoirs are in duplicate and hold 17 M.g. (or about one day's supply). They are covered and well turfed. A Venturi meter measures the water from the reservoir to the city, and its records show that frequently the rate of draft after midnight is 4 to 5 M.g.d., and that it rises in the middle of the day to 18 to 20 M.g.d.

We returned to the hotel about 4 P.M. and took leave of Mr. Solomon, who had been our guide all day. Then we took a car to the International Y.M.C.A. College, where we inspected the air washer and swimming pool.

International Y.M.C.A. College

We were conducted about the college by Dr. James H. McCurdy, who carefully explained the features seen. The first point of interest was the ventilating system, whereby 40,000 cu. ft. of fresh air per minute are supplied to the two gymnasiums, class, locker and toilet rooms. This is an average of 350 cu. ft. per min. per person using the gymnasiums. More air is always being forced into the rooms than is being removed, so that any leakage is from the building outward.

The ventilating plant, which is housed in a special room, consists of two fans (one to force air into the rooms and the other to remove it), a primary heater, a Webster air washer and humidifier with water curtain, spray nozzle, and eliminator plates, and a reheater or tempering coils. The plant is so arranged that either fresh air or recirculated air with or without heating, cooling or washing, or any proportion of the two, may be supplied to the rooms. The plant is thus very flexible, and experiments are being made on recirculation and mixing. It is at once seen that recirculated air means a great saving in coal in the winter months over air drawn from outside, which must be heated before being forced into the rooms.

Also, it was not known whether recirculated air had ill effects upon human beings. Experiments seem to indicate that it is not injurious, and that discomfort is due to the relation between temperature and humidity. There was an entire absence of odors in the recirculated air when washed, although they were pronounced when it was not.

The air from the locker rooms and toilets is drawn by exhaust fans through the backs of the lockers and stools, thus insuring complete ventilation of all garments hung in the lockers and the removal of all odors from the toilets. No odor was perceptible in either of these places.

A summary of the plant may be made as follows:

1. All incoming air may be washed, removing dust and adhering bacteria.
2. Incoming air may be humidified to any degree up to 90% relative humidity.
3. Humidity and temperature are under automatic control, and may be varied at will.
4. The air entering the rooms may be:
   a. Entirely outside air.
   b. Entirely drawn from rooms, washed and humidified, or not, as may be desired.
   c. Any proportion of these two.

A more complete description of the plant may be found in a paper by G. B. Affleck in the *American Physical Education Review*, June, 1912, and in a paper by M. C. Whipple in the October, 1913, number of the *Review*.

Dr. McCurdy gave us the following figures on cost for operation in cents per hour, which he had just received from the engineers operating the tests.

	Heating	Electricity	Depreciation and Interest	Total
Fans using recirculated air	21c.	12c.	19c.	52c.
Fans using outdoor air...	73	13	20	106
Direct radiation, Windows closed	21		4	25
Window ventilation, Windows open	74		22	26

Swimming Pool

We next inspected the swimming pool, 60 ft. by 30 ft. by 8 ft. deep, all of mosaic work. The water was delightfully cool and sparkling, all that could be desired from an esthetic standpoint. This water is filtered through slow sand filters situated in the building. The filters are of such a size that the water is changed every eight hours, and bacterial tests show high efficiency.

Returning to the Hotel Worthy, we had just time enough to get supper and take the 7.25 P.M. Boston and Albany train to Albany. We arrived there at 10.40 P.M., and proceeded at once to our headquarters at Keeler's Hotel.

Albany Filter Plant

Tuesday, May 20.

By 8.30 A.M. Tuesday, we were on a trolley on our way to the Albany slow sand filters, some two miles from the heart of the city. Here we were met by Mr. George E. Willcomb, who conducted us about the plant and furnished us with a wealth of information.

The Albany filter plant is one of the oldest in the country, and is one of the best known to water-works men. It consists, in brief, of a low lift pumping station which pumps water from the Hudson River to a sedimentation basin of 15 M.g. capacity; a group of 16 rapid sand filters, whose ultimate capacity is 30 M.g.d.; 8 slow sand filters, 0.7 acres each, and ultimate capacity of 25 M.g.d.; a pure water well, and coagulating and disinfecting plants.

Albany has a population of 100,000, a little less than Cambridge, but has an excessive per capita consumption of water, being 242 gals. daily in 1911. It has been estimated that the Hudson River at the point of intake contains 1 gal. sewage to 50 gals. of water, thus making it one of the worst used for water supply in this country. At Troy, just four miles above, there are five or six hospitals. Furthermore, 13 M.g. of sulphide liquors pass the intake every year. Thus it is readily seen that Albany has great need of an efficient filtration plant. The

original installation consisted of eight slow sand filters which furnished at the 3 M.g.a.d. rate 16 M.g.d. The city needed 21 M.g.d., so the rest was obtained from gravity sources. The city, however, was growing, and from 1906 to 1908, experiments were made with double filtration. By the use of prefilters, the rate of the slow sand filters was increased to 6 M.g.d., thus giving the plant a capacity of 25 M.g.d. The city used 24 M.g.d. in 1911, so it is seen that the plant is already near its present capacity unless stringent methods are used to cut down the excessive per capita consumption by metering. The Pitometer Company recently made a survey of the city, and reported no leaks in the mains, but a house-to-house inspection has cut the consumption down to 16 M.g.d. Only 30% of the services are metered.

Position of Intake

Opposite the plant is a long narrow island, and to improve navigation in the main river, the U. S. Government has constructed a dike, the top of which is about five feet above low water. This dike cuts off most of the flow through this channel at ordinary stages. At the time the plant was built, it was debated whether the intake should be built across the back channel and island to the main channel, or should take water from the more convenient back channel. In general, the water in the back channel was the better, but there was a city sewer entering the back channel a short distance below the plant, and there was a possibility that the sewage from it would be carried up this channel by flood tides. However, it was thought that there was greater opportunity in the sluggish back channel for sedimentation and natural purification than in the main channel, where the water had come direct from the sewers of Troy.

The intake was built in this back channel, but in 1907 when the prefilters were installed, it was extended through the island to the main channel. The construction was very expensive, as the soil was found to be quicksand. Two contractors lost their outfits, and the work was finally completed by the city with day labor. In all, this short piece of pipe cost $100,000 to lay.

So much having been expended on the intake, it was found necessary to economize on the other construction. Consequently, the number of prefilters was reduced from twenty to sixteen, and much of the superstructure was omitted.

Alum (1 grain per gal.) is added to the water 600 ft. before it enters the sedimentation basin, no coagulant being needed in the prefilters. The sedimentation basin removes about 25% of the bacteria, and 35% of the turbidity, with 17 hours sedimentation. There is 90% reduction in the prefilters, and 94% in the final filters. After leaving the filters, hypochlorite of lime is applied to the water, with an average application of 0.35 p.p.m. of available chlorine. As a result, there is no difficulty in keeping the bacteria count low, the yearly average being less than 50 per c.c.

Sedimentation Basin

It has been found that currents in the sedimentation basin follow along the sides, and it is planned to remedy this by the construction of baffles across the basin. The basin is generally cleaned once in every two years, but Mr. Willcomb says that it should be done at least every year. In cleaning, the basin is out of commission a week. The cost is $200 to $300. About 2000 tons of silt are removed. The coping around the basin is rather in need of repair from the effects of frost, and in its present condition forms a splendid footing for the growth of aquatic plants. It is well in such places to have the coping overhang slightly, and thus prevent such growths. Anabaena and Coelospherium are the most troublesome microscopic organisms. A dose of 2 grains per gal. of copper sulphate is applied every two weeks in the summer.

Prefilters

The prefilters were next inspected, and Mr. Willcomb had one cleaned for our benefit. The upward flow of wash water was at the rate of 1½ vertical feet per minute, for eight minutes, no air being used. The wash water is 4% to 5% of the gross output of the plant, rather high. It has been shown in this

plant that it is much better to store wash water in an elevated tank supplied by a small pump working long shifts, than to install large pumps for short periods of service.

The prefilters operate without the use of alum at the rate of 80 to 120 M.g.a.d. Each unit has a capacity of 1.5 to 2 M.g.d., thus giving the whole plant a maximum daily capacity of 24 to 30 M.g.d.

Final Filters

The final filters (0.7 acre each) are in masonry chambers, the floor and roof being of groined arch concrete, the walls of brick backed with concrete, and the piers of brick. An inclined runway was built in each filter to provide for the removal of the sand by wheelbarrows, but it is now removed by ejectors. Mr. Willcomb uses a Nichols separator for washing, and considers it very efficient. The separator washes and replaces 100 cu. yards per 10 hour day.

Pure Water Reservoir

The capacity of the pure water reservoir is rather small, being 600,000 gals. or one hour's supply. A larger basin of one-half to three-quarters day's supply would have been better. The fluctuations in consumption are met by ample distributing reservoirs, and the pure water well was designed only large enough to allow the pumps to be started at the convenience of the engineer, and give a reasonable length of time for the filters to be brought into operation.

At the present time, every known method of water purification is used in the Albany plant, giving a flexibility of operation that is unrivalled. Many important tests and experiments have been made here, and it is to be regretted that they cannot be given wider publication.

The recent flooding of the Albany plant afforded a clear-cut illustration of what filtration means to a city in the prevention of typhoid. The raw water had access to the pure water well for a very few hours, and the people were at once warned through the newspapers to boil the water before using. After some two weeks of incubation, cases of typhoid began to be

reported, reaching a total of two hundred cases. Seventy-five per cent. of these were children, who probably used the cooler tap water in preference to the insipid boiled water, not fully conscious of their danger. (See Fig. 5.)

To show to what extent economy was the keynote in the construction of the prefilters, Mr. Willcomb stated that they cost $4,000 per M.g., while the mechanical filters at Cohoes, N. Y., cost $12,000 per M.g., and perform the same work.

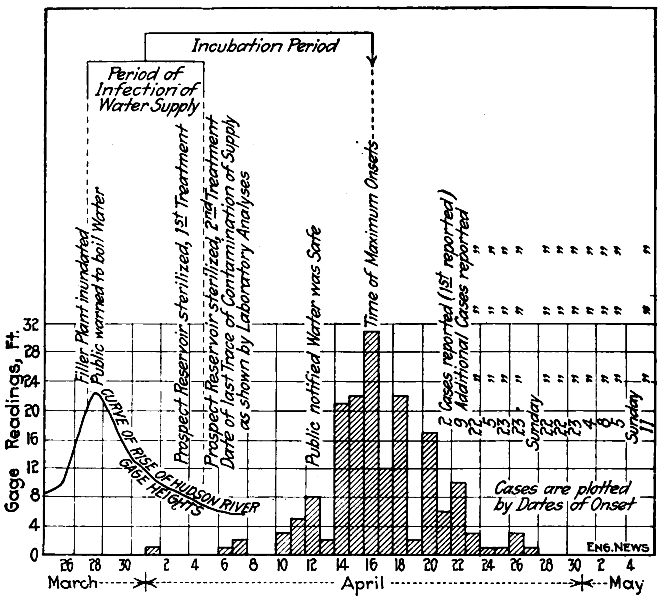


Fig. 5. Recent Typhoid Outbreak in Albany

Cohoes Mechanical Plant

About 12 o'clock, we left the Albany plant for Cohoes, stopping off at Troy for lunch. Mr. Willcomb, who is well acquainted with the Cohoes work, accompanied us. The trip was made by trolley, affording us a splendid view of the Mohawk Falls. At that time of the year, however, no water was flowing over them.

The equipment at the Cohoes plant is very complete, and the results satisfactory, except that sometimes the hydrates pass

through the beds, if the color of the raw water is low. The installation is mechanical, consisting of a sedimentation reservoir of 75 M.g., two coagulating basins of 410,000 gals. each, 10 filter units (8 equipped and 2 blanks), a 500,000 gal. clear well, and chemical tanks for mixing and feeding the solutions to the water.

A 6% solution of 17% alum (1½ grains per gal.) is used for coagulation, and the supernatant liquid from 35% hypochlorite of lime is used for disinfection. The lime dose is 0.25 to 0.33 p.p.m. chlorine. It is seen here that the alum pits

Fig. 6. Cohoes Mechanical Filtration Plant

the concrete tanks, but the deposit of CaCo3 prevents pitting in the hypochlorite tanks.

The beds are washed every 12 hours, using both air and water; air 3½ min., water 3½ min. They are run at a 125 M.g.a.d. rate, and washed when the loss of head reaches 10 ft. The wash water used is 2%, a reasonable figure.

One of the principal features of the plant is the gas producer plant, which was introduced here to reduce the coal consumption to a minimum, as haulage is a considerable item. It was a great contrast from the hot boiler rooms of steam plants, and

this arrangement deserves serious consideration in the design of similarly located plants. The gas produced is supplied to Westinghouse gas engines, direct coupled to 75 KW—125 V— 600 A generators.

About 1¼ lbs. coal, having a heating value of 14,000 B.t.u. are used per brake horse power hour. The producers operate with anthracite coal of buckwheat or pea size, and each is connected to a coke filled scrubber, where the heavier impurities in the gas are washed out by streams of water which trickle down through the coke. The gas is drawn through the producer and scrubber by a Roots exhauster, motor driven. The producers are designed for continuous operation, and are charged at the top through bell valves by a screw conveyor. The bottom of the producer terminates in a concrete pit filled with water, and the ashes are removed readily without breaking this water seal. From the scrubbers, the gas passes into a header pipe, and thence to a gasometer which maintains a constant pressure by the automatic opening and closing of a butterfly valve on the supply pipe. The gas engines are started by compressed air.

The entire plant is very well kept and gives full satisfaction.

Returning to Albany, we took the 5.25 P.M. West Shore R.R. train to Kingston, arriving at 7.30 P.M. We had dinner at Hotel Stuyvesant, and spent the rest of the evening viewing the city.

New Catskill Water Supply

Wednesday, May 21.

(In place of Mr. Rice's excellent brief description of the Catskill Supply, we shall publish, in our January issue, a detailed account of the great work, written by Mr. Charles Brisk.— Editor.)

Thursday, May 22.

The class reported at 9 A.M. at the offices of Hazen and Whipple, 42d Street Building, corner of 42d Street and Madison Avenue. After inspecting the draughting rooms, and meeting the several members of the firm, the party set out for the Bryant Park shaft of the new City Water Supply tunnel.

"From the Hill View reservoir, Catskill water will be delivered to the five boroughs by a circular tunnel in solid rock

reducing in diameter from 15 ft. to 14 ft., 13 ft., 12 ft. and 11 ft. From two terminal shafts in Brooklyn, steel and iron pipe-lines will extend into Queens and Richmond. A cast iron pipe, resting on the harbor bottom, will cross the Narrows to the Silver Lake reservoir on Staten Island, holding 400,000,000 gals. The total length of this delivery system is over 34 miles. The tunnel is at depths of 200 to 750 ft. below the street surface, thus avoiding interference with streets, buildings, subways, sewers and pipes. These depths are necessary also to secure a substantial rock covering to withstand the bursting pressure. The tunnel is being constructed from 24 shafts about 4000 ft. apart, located where they will interfere very little with the traffic. Through these shafts also, the water will be delivered into existing and additional pipes. Of the 24 shafts through which this tunnel is being driven, 23 have reached their full depth and to the end of 1912 nearly 50% of the length of 17½ miles, the longest tunnel in the world for carrying water under pressure, and one of the longest for any purpose had been driven."—*Extract from B.W.S. pamphlet, January, 1913.*

The Bryant Park Shaft, known as Shaft No. 17, has reached a depth of 225 ft., where the tunnel was started. The distance to the next shaft north is 2300 ft. and the diameter is 14 ft. The distance to the next shaft south is 4540 ft. and the diameter is 13 ft. The tunnel is through Manhattan schist. For quite a distance on each side of the shaft, the concrete lining is finished, but we traveled to where it was just being placed. First, 5 ft. of invert is placed, then the sides, and finally the top, as one monolithic piece; collapsible steel forms being used throughout. Wherever there is any leakage through the unlined tunnel, sheet metal plates are placed against the rock. These sag, and the water collecting in the hollows is carried by pipes through the forms. Thus, there is no deterioration of the concrete by the leaching out of the cement before it sets. After the lining has been finished, the holes made by the pipes are grouted under pressure. On our passage through the tunnel, it was noted how free it was from water. In only one or two places did water seep through the grout holes, depositing

iron or lime. When the tunnel is finished it is the intention to place two 4 ft. risers in each shaft, and concrete around them. On the surface will be the gate chamber. At intervals, this procedure is varied by inserting a 6 ft. 6 in. gate at the bottom of the shaft, and having the risers come to the surface through adjacent inclined shafts, thus allowing sections of the tunnel to be shut off and unwatered if necessary.

Professor Winslow's Public Health Exhibit

After the inspection of the tunnel we hurried to the American Museum of Natural History, where we spent an all too brief period at Professor Winslow's Public Health Exhibit. This exhibit is prepared to illustrate in a graphic manner certain phases of water supply and purification and sewage disposal.

Some of the larger models were:

Screen and Grit Chamber.
Septic tank.
Sedimentation tank.
Contact beds.
Trickling filter.
Sand filter.
Little Falls Mechanical filtration works.
Relief Maps of Wachusett Reservoir before and after the construction of the Clinton Dam.
Digging clams near a sewer outlet in New York.
Bathing in Polluted Water.

Kensico Reservoir

In the afternoon we left the city, and inspected the Kensico Dam and aerator. The day was very damp and disagreeable, but the work which we saw at the Reservoir well repaid us for any discomfort.

The Kensico Reservoir is only 30 miles from New York City Hall, and will contain 40 billion gals., of which 29 billion gals. will be available, an amount equal to approximately 60 days' supply at the present rate of consumption. It will act as an emergency storage reservoir, so that the supply will not be in-

terrupted in case of inspection, cleaning, or accident, to the 77 miles of aqueduct between it and Ashokan. The reservoir is formed by Kensico Dam across the valley of the Bronx River, 14 miles above Hill View Reservoir. The normal flow line is at elevation 355 ft., with a maximum depth of 155 ft., or about 110 ft. over the surface of the old Kensico Reservoir which this supersedes. During construction, this old reservoir has been drained. In order to maintain a supply to that part of the Bronx which it formerly served, two substitute reservoirs were built farther up the valley, within the basin of the new reservoir. In the construction of these reservoirs 186 acres of swamp were cleared, and covered with a foot of earth.

Mr. Smith, one of the assistant engineers, conducted us about the reservoir. Considerable care has been taken in the architectural design features of this dam, and a complete model, scale ¼ in. to the ft., has been made of it and is kept on view in the Engineer's office at Kensico. The model, although not in final form, gives promise of an exceedingly handsome structure. This architectural treatment divides the downstream face into panels separated by bands of dimension stone coinciding with the expansion joints (79 ft. center to center), the fields of the panels being of roughly squared stone masonry, the headers being placed in a regular pattern and projecting out from the face.

The expansion joints will be faced on one side with concrete blocks, forming a series of vertical tongues and grooves against which the masonry of the other side will be built. Near the upstream face a copper strip will be inserted in a groove across the expansion joint, and grouted up to act as a water stop, continuous from bottom to top.

Drainage wells 15 ft. apart longitudinally formed of porous concrete blocks, will extend from the top of the dam near the upstream face, to an inspection gallery near the level of the reservoir bottom, which in turn connects with a transverse gallery leading to the downstream face of the dam. The upstream face will be of concrete blocks.

The dam will be of gravity type of cyclopean concrete, with a maximum height of 300 ft. At present about 85% of the excavation is completed. The rock foundation is of mica schist, limestone and Fordham gneiss, all inclined at 60° to the horizontal. In the center of the dam a soft strata of limestone was encountered, and at the time of our visit the engineers did not know how far down they would have to carry the foundation at that point. In another portion of the dam an old river bed of the Bronx River was unearthed. This gorge is carried down 100 ft. below the rest of the dam foundation. The rock is somewhat seamy, and as mentioned before, the seams are nearly vertical and parallel to the side of the gorge. As a result, when the seams were grouted they would simply scale off. To overcome this, as the foundation is laid, risers are tapped into the rock and carried up with the concrete. When sufficient weight of masonry is above them, they will be grouted under pressure. A core wall extends across the upstream toe of the dam, and is always carried 25 ft. deeper than the foundation proper. This cut-off is of 1-2-4 mixture laid very wet.

A novel method of laying the foundation and lower part of the dam is employed here. Instead of using the usual movable cable-ways which extend from abutment to abutment, a distance of 1860 ft., flat-car travelers, each equipped with two derricks, are used. There are four travelers in a group, working between two expansion joints. Tracks for these travelers and for cars bringing materials to them, are supported on concrete piers. The whole system of tracks and travelers will be elevated from time to time as the masonry progresses. The two movable cable-ways now erected are used principally for handling the equipment used on the masonry construction, and are of lock bar type, 2½ in. in diameter. The plant is largely operated by electricity.

After some time at the dam site, we visited the yard where the concrete blocks are made for facing the dam. A traveling platform carrying three concrete mixers, each of 1 cu. yd. capacity, spans the form bed, and moves on rails extending longitudinally through the yard. The forms for the blocks are of steel,

and set in rows along the tracks, so that, as the traveler advances, each mixer will discharge concrete into a separate form. The blocks, when sufficiently hardened, are handled by traveling cranes for storage until sent to the dam. It has been found that the face of the block which is at the bottom of the form is the most impervious, so this will become the upstream face of the dam.

From here, we returned to the dam, and thence to the gate chambers which control the flow from the reservoir. The Catskill water will be delivered into the Kensico reservoir at the upper end of the Bronx valley, where the normal surface of the reservoir, elevation 355 ft., is at the hydraulic grade line of the Catskill aqueduct. The water is drawn from the reservoir through a short tunnel at a point on the west side of the reservoir, about one mile above the Kensico Dam.

This portion of the work is very far progressed. A reinforced concrete by-pass conduit, 11 ft. in diameter and 11,000 ft. long, from inlet gate house at the upper end of the reservoir connects with the upper effluent gate house, so that water may be delivered directly to New York before the completion of the Kensico Reservoir.

We first visited the reservoir end of the tunnel, where the upper effluent gate house is situated, containing sluice gates for controlling the flow from the reservoir into the aqueduct. At the present time the channel of approach is being blasted out to provide easy access for the water from the lower portion of the reservoir. The concrete structure is finished. At the lower end of the outlet tunnel is a large gate chamber in which the flow of the water will be regulated by valves, and either diverted through the Kensico aerator or sent directly through the aqueduct. Near the lower gate house is the screen chamber in which all the water will be passed through fine mesh screens before it flows on toward the Hill View Reservoir.

The aeration will be affected by 1800 nozzles which may be controlled so as to give various floral designs. The aerator basin has a gradual slope toward the centre, in which is a long narrow slot through which the aerated water drops, passing

to the screen chamber, and thence to New York. In a series of interesting experiments here on an aerator at the two substitute reservoirs before mentioned, it was found that there is such a thing as too much aeration. In a conduit designed for 18 M.g.d. it was found that after aeration only 9 M.g.d. could be made to pass through it, due to entrained air. Consequently, a 4 in. pipe was inserted in the conduit just below the aerator, and the escape of air was considerable while the flow of the water increased to nearly 18 M.g. A series of 1 in. holes 9 ft. on centres brought the conduit up to full capacity.

As it was feared that the drop of the aerated water into the chamber below would cause too much air to be entrained, the exit of the chamber is barred by a weir high enough to back the water nearly up to the floor of the aerator when operating at full capacity.

As mentioned before, this work is nearly completed except for setting the nozzles. The inspection of the interiors of the various conduits feeding the aerator, and the aerator well was very interesting. After seeing the screen chamber, we returned to Valhalla Station, Harlem Div., and thence to New York.

FRIDAY, MAY 23.

On Friday morning we took the 8.58 train from the Grand Central Station for Yonkers, where we inspected the slow sand filters, and chlorination plant. This plant has undergone many changes since it was built. At first (1904) two ½ acre open filters were built, and are still in use with no apparent injury except that the exposed concrete is badly cracked. It is unusual to have open filters in the climate of New York, but when built the filters were to be used only in summer to supplement the gravity supply. In 1909, two ¾ acre covered filters were built, of the conventional groined arch type, and connected to the old 200,000 gal. pure water well. At the time of our visit two more ¾ acre covered filters were being built; also a 400,000 gal. pure water well. The work is proceeding under the direction of Mr. H. G. Porter, of Hazen & Whipple. At the present time Yonkers has 85,000 people, and is using about 100 gals. per capita per day, or 8½ M.g.d.

The chlorinating plant was next inspected. The chemical is placed in a perforated box at the top of the solution tank, and a screw pump raises the water in the tank and pours it over it, repeating this process until the chemical is dissolved and the solution well mixed. The feeding device consists of a concrete tank in which the solutions keep at a constant height by means of a glass ball cock. At the bottom of the tank is a projecting pipe and quarter turn, at the end of which is a glass orifice. A throttling valve is inserted between the orifice and the tank, and a glass gauge tube is tapped in between the valve and orifice, thus giving at all times the head on the orifice. By varying the valve, the head is varied, and consequently the flow through the orifice. This head is calibrated directly to the rate of flow of filtered water to the city.

This plant is the antithesis of the Springfield work; and its entire appearance shows vividly the difference between good and bad management. The Yonkers plant since its inception has had no one in direct, responsible charge of operation, and the fact that the results are satisfactory goes to prove that a correctly designed sand filter is something of a fool-proof institution.

Mt. Vernon Sewage Disposal Works

In the afternoon, we inspected the Sewage Works at Mt. Vernon. These include five settling or septic tanks, two sludge beds, five sprinkling or percolating filters (1¼ acres, 8 ft. deep), with overhead nozzles delivering vertical streams to sprayers of the splash plate type, and a final settling basin. The septic tanks, sludge beds and filters are covered. The population of Mt. Vernon is 30,900, and the sewage is 2.7 M.g.d.

The first thing that attracts the attention of the visitor to the plant is the sight of two large towers. These are known as the deodorizing towers containing wood shavings covered with iron oxide, and connected to the sedimentation chambers and filters. It was the intention of the designer to draw the air from the sedimentation chamber and filters through the material in the towers and thus deodorize it. Actually, the towers have never been used except in tests, and seem to represent a

useless outlay of a large amount of money. According to the attendant, there is very little difficulty in obtaining a satisfactory effluent, and this was certainly true the day we were there. Overdosing of the filters is most apt to occur during heavy spring rains. Then pooling occurs, but by May, with the increase of temperature and larvae in the upper layers of the bed, the pooling disappears.

Load on Filter

Population, 30,000.

Size filter, 1¼ acre, 8 ft. thick = 435,600 cu. ft.

12 grams N per day—360,000 grams N per day load.

$$\frac{360{,}000}{435{,}600} = .826 \text{ grams N per cu. ft. per day.}$$

This is a high load, but much sludge is removed in the sedimentation basins. 0.7 would be a good figure.

In the evening we were the guests of Professor George C. Whipple at his home in Flatbush, Brooklyn, and had a very enjoyable time.

Little Falls Plant

Saturday, May 24.

On the last day of our trip we went to the mechanical filter at Little Falls, N. J., of which Mr. F. W. Green is the superintendent. This plant, taking its water from the Passaic River just above the Little Falls, consists of a 1¾ M.g. coagulating basin with 1 1-3 hours' sedimentation, 22 rapid sand filters yielding 1 M.g. each, and a pure water well of 3.5 M.g. capacity. The plant is contained in a two-story structure; the filters, laboratories, chemical tanks and store-rooms being above the coagulating basin and pure water well. Just now they are building a 6 M.g. pure water well to the east of the plant. This is a Jewell installation, being the largest and best managed plant in New Jersey. The plant is owned by the Montclair Water Co., and was constructed in 1902.

Historical

This company was originally known as the East Jersey Water Co., and until 1903 supplied Jersey City, Paterson and Pas-

saic. In 1903 Jersey City opened its own supply and the East Jersey Water Co. began to supply Montclair, West Orange, and Glen Ridge. In 1897, the company commenced the development of a new supply from the Passaic River at Little Falls. The pumping station was completed in 1899, and had a capacity of 75 M.g.d. The plant is located on the north bank of the Passaic River just below the falls. It is a combination water and steam power plant, the pumps being placed between the turbines and the steam engines, and connected so that either water or steam power may be used.

The area of the Passaic Watershed above Little Falls is 772 square miles, of which 181 square miles is appropriated for other municipal supplies. The sanitary quality of the river is fairly good, as very little sewage is discharged into the river. As a rule, the stream is not muddy, although after freshets it carries 25 to 100 p.p.m. suspended matter. The water is often colored, due to passing through swamps at the upper end of the watershed. Frequently, however, the water contains large amounts of amorphous matter, consisting mainly of finely divided organic matter. Much of this seems to come from the bottom of the stream as the water flows for a few miles through great Pierce Meadows, just above the intake where the river has very little slope, and where deposited sediment on the bottom is stirred up by carp and other fish. This produces "dirty water."

From the time the water is diverted from the river by the head race canal, until the filtered water is delivered to the main pumps which raise it to the distributing reservoirs, the flow is entirely by gravity. This made it possible to avoid the cost of extra pumping equipment, but compelled the adoption of relatively expensive, deep structures.

The supply is taken from the river above the Falls and delivered to the plant through a canal and 66-in. steel pipe. The entire filter plant is located in a two story structure 219 ft. by 178 ft. The inlet pipe discharges into a circular concrete tank 10 ft. in diameter, where the water is treated with sulphate of alumina, in quantities necessary to reduce the color below 10.

Thorough mixing is obtained by means of the natural agitation of the water, and it then passes to the coagulating basin. This basin is of concrete 130 ft. by 42 ft. by 43 ft. deep, having a capacity of 75 M.g. This gives a period of coagulation of 1 1-3 hours, when plant is in full operation. Every two months the accumulated sediment, amounting to 2000 tons, is cleaned out by pumping it into the river.

From the coagulating basin, the water flows to 22 rapid sand filters. The filters are of concrete, 24 ft. by 15 ft. by 8 ft. deep with a filtering surface of 366 square feet. The filters are arranged in two separate galleries over the filtered water basin. In each gallery there are two rows of 8-ft. filters. Between and beneath the two rows in each gallery is a pipe gallery, above which is the floor on which the operating tables are located.

The normal rate of operation of each bed is 1 M.g.d., the rate being governed by Weston controllers, the valves being operated by hydraulic cylinders. On each operating table is a loss-of-head gauge, and the filter is washed when this reaches 9.0 feet. In washing, the sand is first agitated by air being forced through the strainer system for three minutes. This is followed by a current of filtered water for six minutes. The air is furnished by Sturtevant blowers, and the wash water by special pumps. All the machinery is electrically driven.

Beneath the filters, and adjacent to the coagulating basin, is the clear water well. This is in two compartments, 124 ft. by 58 ft. by 29 ft. deep, capacity, 35 M.g. As the water leaves the clear well, it is dosed with calcium hypochlorite in the proportion of about 0.2 p.p.m. available chlorine per M. gals.

The coagulating basin is covered with a flat roof, which forms the floor of the main building. This building is 132 ft. by 46 ft., and contains the machinery room for the rotary blowers, pumps and devices for applying coagulant, storage for same, and also the laboratories, offices, tool room, wash rooms, and lockers.

Every eight hours tests are made on raw, coagulated, filtered and delivered water for turbidity, color, and bacteria at 20° C,

and on raw and delivered water for alkalinity, and the alum and hypochlorite solutions are tested for strength. Presumptive tests in dextrose broth for Bacillus coli are made once a day on river, filtered, and delivered water. Complete chemical analyses are made once a month. Once a week, microscopical analyses are made on water in all the reservoirs.

Upon our return from Little Falls, the party officially disbanded. In conclusion, I would like to call attention to the unfailing courtesy of the engineers and officials with whom we came in contact.

[The illustrations are from photographs taken on the trip, with the exception of the diagram showing the typhoid outbreak at Albany, which is kindly loaned by *Engineering News*.—EDITOR.]

SOME NOTES ON PAVING

CLARK R. MANDIGO, '06*

As all engineers are more or less interested in the difficulties encountered by their associates in other lines, it is hoped that a brief recital of some of the problems in street paving which confront the average municipal engineer may be of general interest to readers of the HARVARD ENGINEERING JOURNAL. It is not intended in this short article to elaborate on the technical trials and tribulations, which are more or less common to all branches of the engineering profession, and which are, in the nature of family quarrels, not to be paraded before the public; but to point out briefly some of the economic problems which should be carefully considered by all good citizens in providing satisfactory pavements for our city streets.

In the first place, a great deal of money has been wasted in paving wider roadways than there is any necessity for. Fortunately, present good practice is correcting this waste by paving narrow roadways on the majority of residence streets, and at the same time providing ample room for traffic on a few arteries of travel. The minimum width of roadway should not be less than 22 ft. between curbs, except on unimportant side streets, and preferably not less than 26 ft. With a double street-car track, the minimum width of roadway should not be less than 42 ft., although 36 ft. might do, and on busy streets not less than 54 ft.

Another source of financial loss to taxpayers is the usual haphazard method of selecting the kind of pavement for particular streets. This evil is chronic with most cities at the present time, and is due to a number of causes:—

1. The city charter may require the property owners, the City Council, or an Elective Board, to name the kind of pavement; or

*Assistant City Engineer, Kansas City, Missouri.

2. Bids may be received on a number of different kinds of pavement and the choice made after bids are opened; or,

3. The proper attention and advice to the selection may not be given by the engineering department.

There are, of course, a number of contributing causes, but these are usually interwoven with more than one of those named above. If (1) obtains, a pavement is selected because of its cheapness or finished appearance rather than its suitability

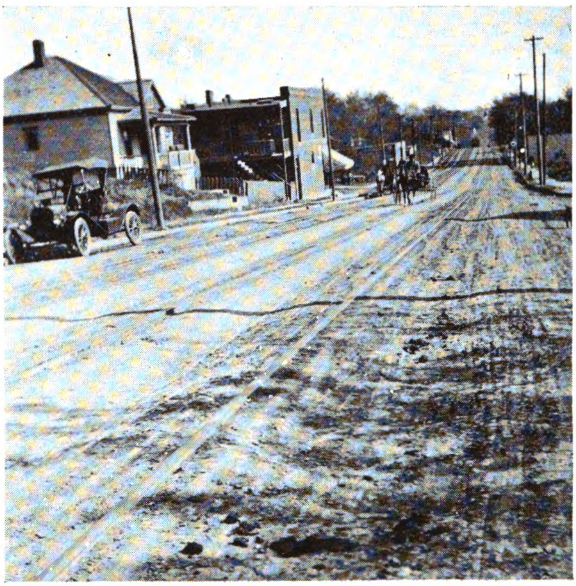


Fig. 1. An Economic Failure for Macadam Pavement

or durability. Property interest is often only transitory. Case (2) gives paving promotors an opportunity to "Work their rabbit's foot" and a selection is usually made from other considerations than the particular needs of the street itself. The general lack of appreciation of the value of the services of a competent engineer accounts for the condition stated under (3). Changes in municipal officials are frequent and the selections in the engineering lines are not always based on qualifications as

municipal engineers. As a consequence, a good railroad or structural engineer, on becoming a city engineer, is so overburdened with the ordinary routine details that he has not the time to study the underlying problems of his work.

Possessed of a thorough knowledge of the qualities and limitations of the various pavements, a municipal engineer should make recommendations as to the kind of pavement which a close study of the present and future traffic needs of each particular

Fig. 2. Ideally Located Macadam Pavement on Park Drive, Restricted to Pleasure Vehicles

street indicate is the most economical. No paving material is of universal application and every mistake in location is costly.

For instance, Fig. 1 is a photograph of a macadam pavement which carries a large amount of heavy horse-drawn vehicular traffic confined by the car tracks and curb to a narrow strip. The crooked pole shadows indicate the extreme unevenness of the surface. At the time the photograph was taken the pavement was three years old and had not been repaired for nearly a year. The cost of repairs was very heavy the first two years,

and the pavement was afterwards allowed to deteriorate on account of lack of funds. The pavement was a fairly well constructed tar-bound macadam, but it could not be expected to hold up under the conditions imposed. In contrast to this, Fig. 2 shows a macadam road of somewhat cheaper construction which is over five years old, and has been kept in perfect condition at a very low cost per year. It is on a park drive restricted to pleasure vehicles, there being a very heavy automobile

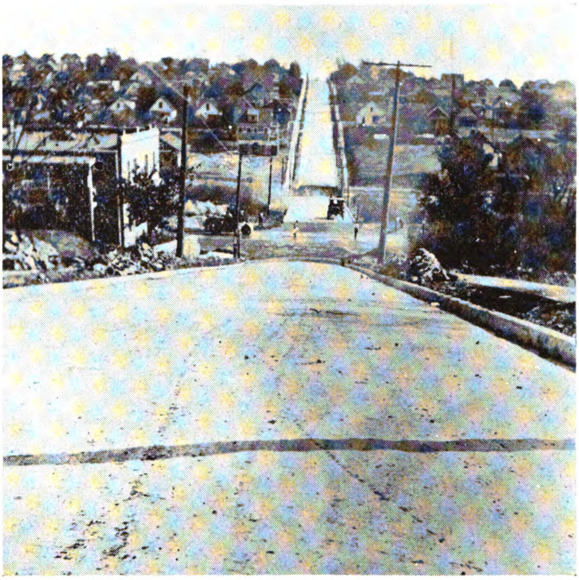


Fig. 3. An Ideal Location for a Plain Concrete Pavement

traffic, and is maintained by two applications of light asphaltic oil each year.

One pavement is an economic failure because the limitations of the soft local stone macadam construction and traffic conditions were not recognized; the other is ideally located because those limitations were recognized.

In any city there are new, outlying residential streets along which the property is cheap and builds up slowly. These streets need an inexpensive pavement of a temporary nature until the

public utilities have been laid beneath the street and the property built up. Heavy grades and soil conditions may also require paving streets through long stretches of vacant property either to protect them from washing or to provide traffic communication with other property lying beyond. In these cases, the pavement which gives the most service for the money invested is the plain concrete paving.

Fig. 3 shows a proper location for this class of paving. The concrete paving on this street, costing one dollar per square yard, has a pleasing appearance and will last just as long as a brick block pavement at twice the cost.

The foregoing illustrations indicate that very serious mistakes can be made in the selection of a pavement without a close study of local conditions and probable future traffic needs. There is no form of pavement which is satisfactory under all conditions. In fact specifications are being constantly improved and revised in order to get a construction which will withstand the increasing severity of traffic. Not many years ago the advent of the pleasure automobile upset country highway construction; now the arrival of the 5, 10, and even 15-ton auto-truck is causing consternation among municipal engineers. Every tendency toward increased auto-truck traffic decreases the importance of the wearing surface and increases foundation troubles. The problem of providing a pavement which will weather and sustain loads,—the prime conditions to meet in auto-truck traffic only,—is simple enough. But the selection and specification of a pavement which will not only meet the present mixed traffic but will also prove satisfactory for the probable future development of fifteen or twenty years, the minimum life of a good pavement, becomes a serious question. Care and money spent by the citizens in seeking expert advice on the subject of paving, means the saving of large amounts in the future.

UNNECESSARY STUMBLING BLOCKS

CALVIN M. WOODWARD, '60*

All writers appear to regard Mechanics as a difficult subject. Experienced and successful teachers do not hesitate to speak of the "Many points with which students always have difficulty"; of "the pitfalls" and "difficult theorems"; of the "usual difficulties which beset students." One well known, eminent teacher and author declares that "Mechanics affords more difficulty in its mastery than all other subjects together." My own experience in the class room and in the examination of text-books leads me to add that not students alone, but writers of books have suffered in pitfalls, and been vanquished while struggling for mastery of the very foundations of Applied Mechanics. I do not claim that there are no difficulties, but I do claim that many stumbling blocks have been injected into courses which do infinite harm, from which students too often never fully recover. Some of these gratuitous impedimenta I wish to point out.

1. *The emphasis put upon Reactions.* It would have been better if Newton had never dignified a self-evident truth by calling it a fundamental law: that, an "Action and its Reaction are equal, simultaneous, and directly opposite." Some writers actually seem to think that an action and its reaction balance, as though they act upon the same body! By example, if not by precept, they lead their readers (students) to dwell upon the reaction, when only the action is properly under consideration. How often do we see in print: "Since forces always occur in pairs." Confusion worse confounded! What can the boy make of it? He thinks if they oppose each other, the result is nil; if they act together like a pair of oxen, the effect of one is doubled. Neither can be true. What is a "pair"? Do a man-eating lion and a man hunting a lion constitute a pair of hunters? Forces can balance only when acting on the same body. Two bodies,

---

* Professor Emeritus of Mathematics and Applied Mechanics, Washington University, St. Louis.

A and B, may so act upon a third body as to balance. There can be no balance of forces without at least three bodies. If a heavy ball rests upon a table we have an example of two forces which balance. Yet three out of four Freshmen who have studied Physics (perhaps also that proportion of the teachers) will analyze the situation thus: "The ball acts down upon the table, and simultaneously and equally the table acts up upon the ball, according to Newton's third law, so that they balance and the ball is at rest." It is no wonder that students find Mechanics "difficult," and "hard to understand" when taught such nonsense. The correct analysis, I hardly need say, is: The ball is acted upon by two bodies in such a way that those two actions balance. One acting body is the earth, which acts upon the entire volume of the ball, by what is known as gravitation, a downward pull. The second acting body is the hard surface of the table, which acts vertically upwards upon the ball, completely balancing the pull of the earth; hence the ball is at rest. I admit that this talk may appear like a kindergarten lecture, but I feel assured that it will not appear so very simple to every pupil who enters upon a systematic study of mechanics.

2. The introduction of such phrases as the "force of inertia," the "force of momentum," etc. are stumbling blocks. To illustrate: A boy, by means of a horizontal string, pulls with a force of ten pounds a block of smooth ice which slides over the smooth ice surface of a pond. Some would teach that the tension in the string is due to the force of inertia of the ice, instead of simply saying that the tension is exactly due to the action of the boy. Of course, if there were no ice there would be no action upon ice, and there would be no problem. But the magnitude of the block has nothing to do with the magnitude of the force acting upon it. The block may weigh a ton, or 50 lbs., or 10 lbs., or ½ lb., the action of the boy is still 10 lbs. The words "force of inertia" exhibit a misuse of language, which always causes the reader to stumble. Take the block of ice again, which is now in motion. Suppose the string is cut; the ice keeps moving. What keeps it moving? Some one will say, the force of inertia or the force of momentum. Absolutely wrong. Only two

forces are acting on the block, and they balance: gravity, and the lift of the pond ice. (The ice is supposed smooth and the air pressures balanced.) There is no other force, notwithstanding certain writers, who shall be nameless. An Elementary Physics, which I saw recently, explained the motion of a projectile fired in a vacuum by saying: "It is acted upon by two forces: gravitation which acts down, and the force of inertia which carries it forwards." What a stumbling block is that!

3. Somewhat similar to the last is the blunder of a writer of Mechanics for College Students. He is discussing the motion of a conical pendulum, whose moving ball describes a horizontal circle. He says: "Three forces are acting upon the moving ball: gravitation, the tension in the pendulum rod or thread, and the centrifugal force," which balances the other two. What will become of students who stumble over such a statement as that? Will they ever see clearly that the ball is acted upon by only two forces which do not balance; and that consequently the ball is not moving under balanced forces? "Centrifugal Force" is a big bugbear. In the above problem there is no centrifugal force, and there should be no use of the expression. The resultant of the two forces acting on the moving ball is properly called a deviating force, because it compels the ball to keep a circular path, thereby deviating from a straight course at every point. In spite of countless authorities (?) to the contrary, there is no force acting on the ball in question tending to make it "fly the center."

4. All writers admit the importance, when considering the motion or rest of a definite body, of recognizing carefully how and where other bodies are acting upon it. To that end the roll is called, as it were, and the several actions are noted, known or only partly known. No attention need be given to reactions upon other bodies. The sole question is: How does this other body act upon the definite body under consideration? This concentration of thought upon the state of behavior of the one body is sometimes described as giving it "freedom" or "isolation." The thought is eminently proper, but the words chosen as names are stumbling blocks most assuredly. A body is isolated only

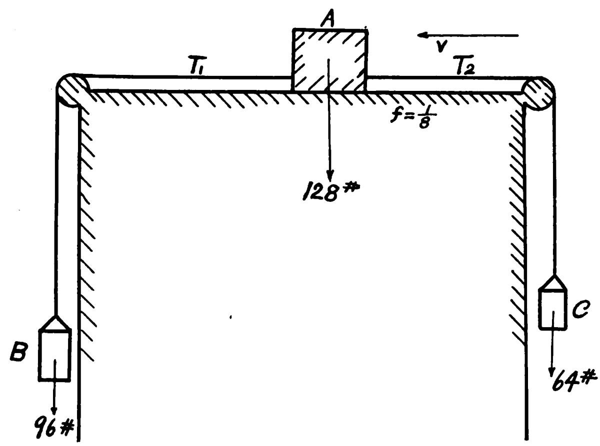
when it is alone, with no other body in the universe to act upon it; and it has perfect freedom only when so isolated. I have not looked up very many writers on Mechanics, but the use of one or both of the unnecessary words is sufficiently general to justify my quoting two. One author, generally very clear-headed, says: "A rigid body is made free by conceiving the actions of all other bodies as forces." How could one conceive otherwise? Having been told that force is an action between two bodies, how can it be necessary to conceive that the actions are forces? and how can such a conception make a body free? There certainly is in the quoted words a suggestion that there is some hidden distinction between a "force" and an "action." The reader is left much at loss.

Again, the same author says more explicitly: "The free-body method consists in conceiving the body isolated from all others which act upon it in any way, *those actions being introduced as so many forces.*" The italics are mine. It is here again hinted that forces and actions are different things. The actions are first cut off, and then brought back (introduced) as forces. When is the body "free"? When it is isolated from all other bodies acting on it? or when those actions are "introduced" again as forces? What is gained by thus marching up the hill and marching down again? Perhaps the idea is that when the actions are "introduced" as forces (like guests at a formal reception) their individual identity is emphasized. But what will the student beginning Mechanics make of the definition? Will he not stumble, and stumble in wretched confusion? Why say anything about freedom or isolation? Is it not enough to take up every action upon the body under consideration, note its character, its magnitude, position, and direction, so that if a drawing be made it may fairly be represented by an arrow?* So long as we are considering only the condi-

[*As the term is used at Harvard, to "isolate" a body means simply to concentrate one's attention on that particular body and the forces which act upon it. As one writer puts it, to "isolate" a body means to "draw a figure indicating by arrows all the forces which act on the body at a typical instant." Professor Woodward would doubtless have no objection to the use of the term isolation in this restricted sense.—EDITOR.]

tions of rest or motion of the definite body there is no occasion to think of the effect of reactions upon the acting bodies. The definite body is always acted upon; as the grammarian would say, is in the "passive voice."

If we were considering the work a moving body does, the case would be different, but that case is not now before us. Perhaps it is worth while to illustrate by the solution of a simple problem which comes naturally under the head of translation caused by constant forces, in the solution of which no body is isolated, and no body is made free by cutting off the actions



of other bodies. The figure shows three bodies, A, B, C, connected by ideal cords (strong, flexible, and weightless). The corner guides are smooth, but the horizontal plane is rough, with a coefficient of friction of 1/8. The bodies are moving with a common linear velocity v as shown. We are to find their common acceleration, and the values of the two tensions T and T_2.

Solution: Four forces are acting upon A; the unknown tensions T_1 and T_2, the pull of the earth 128 lbs., and the action of the rough plane, which we may resolve into a vertical compo-

nent 128 lbs., and a horizontal component 16 lbs. Since the earth's pull and the vertical action of the plane completely balance (or pair off) we can drop them from our thought. Our resultant force, acting in the direction of motion, is

$$F_A = T_1 - T_2 - 16;$$

hence we have by the fundamental equation of kinetics,

$$\frac{T_1 - T_2 - 16}{128} = \frac{a}{g} \qquad (1)$$

in which a is the acceleration sought. The values of T_1 and T_2 are to be found by considering the motions of the hanging bodies B and C. B is acted upon by two forces, the pull of the earth, and the action of the cord T_1. Hence:

$$\frac{96 - T_1}{96} = \frac{a}{g} \qquad (2)$$

Similarly, considering C we get:

$$\frac{T_2 - 64}{64} = \frac{a}{g} \qquad (3)$$

From (1) and (3) we get:

$$\frac{T_1 - T_2 - 16}{128} = \frac{T_2 - 64}{64} \qquad (4)$$

$$T_1 - 3T_2 = -112$$

From (2) and (3) we get:

$$\frac{96 - T_1}{96} = \frac{T_2 - 64}{64}$$

$$2T_1 + 3T_2 = 384. \qquad (5)$$

From (4) and (5) we get:

$$T_1 = 90\tfrac{2}{3} \text{ lbs.}$$

By substitution we get:

$$T_2 = 67\tfrac{5}{9} \text{ lbs.}$$

$$a = \frac{g}{18} \text{ ft.}$$

If we had wished for a only, we should have considered the bodies A, B, and C as parts or members of a train or system, and ignored the cords and their tensions, as the latter are only internal stresses having no influence upon the unbalanced force which moves the train, just as have the internal stresses in the solid bodies, A, B, and C. The external forces acting upon the train are the earth and the plane. The earth acts at three points, A, B, and C, the actions being 128, 96, 64 lbs. respectively. The action at A is completely balanced by the vertical action of the plane. The action at B is partly balanced; that at C is overbalanced. The horizontal action (friction) of the plane on A is unbalanced. Hence the resultant unbalanced force action on the train in the direction of motion is,

$$F = 96 - 64 - 16 = 16 \text{ lbs.}$$

The total weight of the masses whose motion is accelerated is,

$$W = 96 + 64 + 128 = 288 \text{ lbs.}$$

Hence $F/W = 16/288 = 1/18 = a/g$. Therefore $a = g/18$ as before.

If now the values of T_1 and T_2 are wanted they are readily found from equations (2) and (3).

There has been no occasion in this analysis to quote Newton's 3d law, or to premise: "Since forces always occur in pairs." To do either would have tended to distract the attention and upset the reader. If someone asks: "How do you know that the vertical action of the plane is 128 lbs.?" I answer, "Not by the law of reaction, but because there is known to be no vertical acceleration, hence the action of the plane and the pull of the earth

must balance. Had there been a vertical acceleration, the action between the plane and A would not have been 128 lbs."

There are many other stumbling blocks in printed books and in the inherited prejudices of teachers, which ought to be removed; but as to prejudices, they stick closer than a brother, like the old doctrine of phlogiston, and Nature's horror of a vacuum. But this must do for today.

HARVARD ENGINEERING JOURNAL

A Quarterly

DEVOTED TO THE INTERESTS OF ENGINEERING IN HARVARD UNIVERSITY

THE OFFICIAL ORGAN OF THE ASSOCIATION OF HARVARD ENGINEERS

Published four times during the college year by the Board of Editors of the Harvard Engineering Journal in November, January, April and June.

Subscription Rates

Per year, in advance	$1.00
Single copies	.35

Advertising rates will be furnished on application to the Business Manager. Address all communications to the heads of the respective departments:—

Harvard Engineering Journal,
Room 218, Pierce Hall,
Cambridge, Mass.

Entered at the Post Office, Boston, Mass., as second-class mail matter, June 5, 1902.

A most pleasing finale to the work in Sanitary Engineering for the year just closed was the "Farewell Supper of the 1913 Sanitary Sons of Harvard, tendered to the Faculty of Sanitary Engineering at the Thorndike, June 3, 1913." The occasion was a testimonial from the men who had taken advanced work in

Sanitary Engineering (Courses C19d, e, and f) of their appreciation of the efforts of the members of the department under which they had studied during the past year.

The sentiment expressed in this form was especially gratifying to Professor Whipple and his assistants as being incontrovertible evidence that there had been aroused in these students, not only an interest in their work, but also the spirit of coöperation with, and affection for their school which must inevitably assist in establishing for it a firm and enduring foundation.

The good fellowship of the occasion was enhanced by the novel features introduced from time to time during the dinner by the committee in charge, the most remarkable of which from all points of view was the menu. This took the form of a folio of blue prints of standard "sanitary" note size with dimensions plainly lettered according to the regulations laid down by Professor Whipple for his courses. The cover, in addition to the title quoted above, contained a panel drawing in cartoon style which depicted the name of each individual diner and so served as a place-card. The cycle of Nature, from the bacteria—through the micro-organisms in water, the fish—to man, depicted graphically, served as a decoration.

The menu under the caption of the "Cheezy Formula," a travesty of pseudo-scientific and highly insanitary sounding terminology, was successful in completely mystifying the diners as to its meaning, and was a source of periodic and violent mirth as each course was served. The close of the dinner was devoted to "Ventilation," and the airing of opinions, serious and frivolous, was highly entertaining.

The occasion will long be in the memory of those who were present. The links of friendship, fashioned in mutual interests and coöperative effort throughout the year between students and instructors were here welded into enduring bonds that already have extended their span to the south as far as Florida, and to the east to far-off China, as the graduates in Sanitary Engineering in 1913 have scattered to undertake the work of their chosen careers.

The JOURNAL feels that a distinct gain has accrued to the Edgineering School through the spirit of loyalty which has been engendered in this group of men, so clearly expressed on this unusual occasion.

Professor Albert Sauveur of the faculty of the Mining School has recently been awarded the Elliot Cresson gold medal by the Franklin Institute, of Pennsylvania, in recognition of his numerous and important contributions to the science of metallography, and of his successful endeavors for the practical application of his discoveries in the iron and steel industry. This medal is the highest award which may be bestowed by the Institute.

Professor Sauveur was born in Louvain, Belgium, in 1863. At an early age he came to this country, and a little later entered Massachusetts Institute of Technology, where he completed a course in mining and metallurgy. In 1889 he was graduated from this institution and until 1898, he served as chemist and metallurgist to several steel companies. Since that time, he has devoted his career to metallography, as investigator, educator, and author. As manager and proprietor of the Boston Testing Laboratories, from 1897 to 1905, he edited and contributed to the *Metallographist,* a quarterly publication by that institution. In 1903 the *Metallographist* was succeeded by the *Iron and Steel Magazine,* which Professor Sauveur edited and published for three years.

As an author, Professor Sauveur is well known. He was the first in this country to write and publish articles directly applicable to the practical processes of the iron and steel industry. In 1893 his first paper on "The Microstructure of Steel" appeared in the "Transactions of the American Institute of Mining Engineers." Following this, he has written many papers and textbooks, the latest of which, a paper on "The Microscope in the Iron and Steel Industry," was presented at the last annual meeting of the Iron and Steel Institute and published in the Iron and Trade Review, of June 5, 1913.

His most important discoveries have been concerned with the effect of temperature upon the finishing of iron and steel prod-

ucts. He has shown that the cooling of steel before rolling, drawing, or moulding, instead of treating at a white heat as formerly, increases its ductility from 10% to 20%, thus reducing its brittleness one half. These discoveries have already greatly effected the automobile industry and the manufacture of steel rails; the new method of treatment making possible stronger steel for the chassis, in the former, and affording a stronger, more tenacious, and more ductile material, in the latter.

Professor Sauveur has been connected with Harvard University for about fifteen years, and in addition, he has delivered numerous lectures at Massachusetts Institute of Technology and other scientific institutions.

The Committee of Management of the International Engineering Congress, 1915, takes great pleasure in announcing that Col. Geo. W. Goethals, Chairman of the Isthmian Canal Commission and Chief Engineer of the Panama Canal, has consented to accept the Honorary Presidency of the Congress and will preside in person over the general sessions to be held in San Francisco September 20-25, 1915.

"Harvard and the Massachusetts Institute of Technology open this year their new joint school for Health Officers. The purpose of this school is set forth in its title. The administrative board of the school consists of Professor William T. Sedgwick, of the Massachusetts Institute of Technology, chairman; Professor Milton J. Rosenau, of the Harvard Medical School, director; and Professor George C. Whipple, of the Harvard Graduate School of Applied Science, secretary."

Harvard Alumni Bulletin, Sept. 24, 1913.

ASSOCIATION OF HARVARD ENGINEERS

The annual dinner of the Association of Harvard Engineers and the Harvard Engineering Society was held in the Harvard Union Wednesday, June 18. Mr. B. B. Thayer, president of

the Association, presided. Between the courses of the dinner, Association members considered the regular business of the year.

It was voted to adopt the following amendment to the Constitution:

In Article III, Sec. 1, strike out the words "whether educated in engineering in Harvard or elsewhere,—insert after "is" the words "or has been at any time,"—strike out "professionally, or associated as owner or director,"—strike out "in any of its branches" and insert in place thereof the words "or science," so that the section will then read:

Section 1. Membership shall be open to any former member, past or present officer, or any honorary degree holder of Harvard University, who is or has been at any time identified with Engineering or Science and who wishes to coöperate with the purposes enumerated in Article II.

The officers elected for the year 1913-14 were: Franklin Remington, president; W. C. Sabine, E. D. Densmore and A. C. Jackson, vice-presidents; F. L. Kennedy, treasurer; J. F. Vaughan, secretary; Langdon Pearse and H. E. Clifford, members of the Council for three years; J. R. Nichols, member of the Council for two years, replacing J. F. Vaughan.

It was thought best to try again the new date for the dinner; i. e., some time during Commencement week.

After the business meeting and dinner, John Hays Hammond and Hennen Jennings spoke briefly, and stereopticon lectures were given by Professor J. F. Kemp of Columbia, who illustrated an amusing imaginary journey in search of the North Pole, and by Dr. S. H. Chuan, who described his very interesting pictures of Thibet.

Those present were:

Classes of 1854 to 1887.—Charles H. Hudson, '54; W. E. C. Eustis, '71; Arthur F. Clarke, '76; Hennen Jennings, '77; J. R. Worcester, '82; R. A. F. Penrose, Jr., '84; Henry M. Williams, '85; Victor C. Alderson, '85; B. B. Thayer, '85; Henry Bartlett, '85; Henry L. Abbot, '86 (Hon.); L. J. Johnson, '87; Franklin Remington, '87.

Classes of 1890 to 1898.—Albert F. Brown, '90; F. L. Kennedy, '92; H. J. Hughes, '94; J. F. Vaughan, '95; Cabot Stevens, '95; W. E. Clark, '95; Francis Mason, '96; C. S. Dow, '97; J. A. Butler, '98.

Classes of 1901 to 1908.—J. W. Hudson, '01; Charles Gilman, '04; A. E. Kennelly, '05 (Hon.); D. L. Furness, '05; I. N. Hollis, '06 (Hon.); J. R. Nichols, '06; Mark Linenthal, '07; H. S. McDewell, '07; A. B. Green, '07; C. C. Pope, '08; E. N. Hutchins, '08; G. A. McKay, '08; L. A. Doggett, '08.

Classes of 1910 to 1914.—Warren Ordway, '10; G. W. French, '10; M. M. Warren, '10; K. R. Garland, '10; T. R. Kendall, '12; L. N. Clinton, '12; C. H. Marsh, '12; C. E. Holmes, '13; C. W. Burrage, '13; W. B. Harris, '13; A. B. Haw, '13; W. N. MacGowan, '14.

Graduate School.—Dr. S. H. Chuan, F. M. Meader, R. S. Ould, R. B. Pendergast, L. W. Weed.

Others present: Professor W. H. Burr, John Hays Hammond, Professor J. F. Kemp, A. W. Rayner, Professor Albert Sauveur, Professor G. C. Whipple.

HARVARD ENGINEERING SOCIETY OF NEW YORK

The annual meeting of the Harvard Engineering Society of New York was held on Saturday, June 7, on the grounds of the New York Athletic Club, Travers Island, N. Y. About 75 members were present. Through the courtesy of Thomas W. Slocum, '90, the company made the trip to and from Travers Island in Mr. Slocum's yacht "The Ranger." The annual dinner was held in the club house.

The following were elected officers of the society for the ensuing year: President, J. R. Finlay, '91; vice-president, Thomas Crimmins, '00; secretary, Charles Gilman, '04; treasurer, C. M. Holland. Executive committee,—the four officers already given; the following former presidents of the Society, John R. MacArthur, '85, Francis Mason, '96, and Arthur C. Jackson, '88; and Warren Delano, '74, Clifford Richardson, '77, Sidney J. Jennings, '85, John R. Healy, '97, Ralph R. Rumery, '99, Roger C. Barnard, '02, and Dean G. Edwards, '03. Advisory Commit-

tee: George S. Rice, '70, Franklin Remington, '87, B. B. Thayer, '85, all former presidents of the society; and H. M. Hale, '04, a former secretary of the society.

HARVARD ENGINEERING SOCIETY

The first meeting of the Harvard Engineering Society was held in Conant Common Room on Friday, October 10, at 8 o'clock. An amendment to the constitution was adopted, raising the Society dues from $1.50 to $2.00 per year. The fee for associate membership remains the same. After the regular order of business the meeting was addressed by the members of the Faculty of Engineering who were present.

Professor Hughes emphasized the fact that engineers need to know each other well and that the School of Engineering is the place to make friends with others with whom you are likely to come in contact in later life. Doctors and lawyers hang together naturally—they have to. But each engineer must stand for himself, a thing which makes the formation of early friendships important. This school is the first one of its kind. We hope it is the best. Certainly it has a most eminent Faculty. Its object is to give a solid foundation in real engineering—not "super-engineering." At the base of the School are the students who go out from it. On them, and the mark they make, depends the whole future of the School. "It is to the students that we look to advertise the School."

Professor Johnson said that one of the great neglected opportunities of the engineers is to turn their peculiarly well adapted character to the really big questions of the country. The two striking features in the character of a good engineer are intellectual sobriety and audacity. He is wise and painstaking in his judgments, and he will not be bluffed by aged nonsense. Certainly in the great political questions of the day, engineers could not make a worse job of it than has been made heretofore. Professor Johnson read parts of a letter from Gradolph, who is studying in Zurich.

Professor Norton spoke of the way the meetings of the Society were conducted several years ago when the custom was to

have speeches by prominent engineers from various parts of the country. The speeches were fine, but the attendance was not always a credit to the Society, and beside that an opportunity for much valuable training was lost. One of the commonest tasks of a practicing engineer is to condense all the fruits of hours and even days of preparation into a ten minute talk with his client or a quarter of an hour trying to convince a board of directors. It is most important for every engineer to be able to present the results of his work, not only in a creditable, but in a convincing manner. It is training of this sort that the meetings of the Engineering Society gives. Talks need not be elaborate, if they are made with force. Professor Norton also noted the change in the type of man, which is taking place in the Engineering School. It is no longer the sewing machine and doorbell expert who is going to be an electrical engineer, but a man of broader and wider interests who has chosen engineering as a profession. The group in the school now is intent on making friendships and getting a deeper training than the mere instruction of the courses. The extra years, beyond those spent in college, are not an extra tax on the man's time, but an additional opportunity for advancement.

Professor Huntington expressed his appreciation of the fact that engineers and mathematicians are getting together. The conflicts between them a hundred years back are astonishing to us. And it was not so very long ago that the bonfire of Calculus texts was the logical end of every course in the subject. Those days are gone; and any book of the last ten or twenty years lays much stress on the very interesting applications of the subject. This is largely due to the pressure brought to bear by engineering students. It is a well recognized fact now that every good engineer wants a firm foundation in mathematics. Certainly the unity of purpose and unity of interest now existing between mathematicians and engineers is a very encouraging sign.

Mr. M. C. Whipple gave the Society his greeting, after which the meeting was adjourned.

E. L. ROBINSON, *Secretary*.

HARVARD WIRELESS CLUB

The Harvard Wireless Club will soon hold its first meeting of the year, with prospects of a very interesting year in view. The location of the club room has been changed. The club now occupies room No. 70, College House, where a new and improved antenna will soon be erected. Several additions to the apparatus have been made, and it is expected that, when the station is opened for use, the Club will have one of the best instruments in the vicinity. Several different varieties of receiving apparatus will be tested during the winter, thus affording opportunity for the study and comparison of various types of receivers. The prospects are bright for a most successful and instructive year for the Club.

E. T. Drake, Jr., *Manager.*

GRADUATE NOTES

(On account of the many inquiries as to the whereabouts of the graduates of the department, it is hoped that the Graduate Secretary will be notified of changes of address and occupation, etc. Such notes will appear promptly under this heading.)

Francis A. Houston, '79, who has been for several years general manager of the New England Telephone and Telegraph Company, was elected treasurer of the Company at its recent annual meeting.

Howard Elliott, '81, has been chosen executive head, with full power, of the New York, New Haven and Hartford Railroad, after ten years' service as president of the Northern Pacific Railway.

Asaph Hall, '82, was in Paris last spring as one of the commission to investigate wireless time signals for the United States Naval Observatory.

J. E. Allison, '87, has resigned his position as commissioner and chief engineer of the Public Service Commission of St. Louis, Mo., and formed the firm of James E. Allison and Company, consulting engineers.

ALBERT F. HOLDEN, '88, of Salt Lake City and Cleveland, one of the best known mining engineers in the country, and formerly part owner of the Boston Traveler, died at his home in Cleveland on May 18.

FRED A. HUNTRESS, '91, is vice-president of the Rio de Janeiro Tramway, Light and Power Company, Rio de Janeiro, Brazil.

L. FRASER, '93, is acting as consulting mineralogist to the Harris Laboratory at 86 Fulton St., New York, N. Y.

WILLIAM R. DRIVER, JR., '94, who has been general superintendent of traffic of the Bell Telephone Company of Pennsylvania, has been elected general manager of the New England Telephone Company.

WALTER M. BRIGGS, '95, has been elected secretary and treasurer of the Tennessee Copper Company, 2 Rector St., New York. He is also treasurer of the Ajo Consolidated Copper Company of Arizona, and President of the Regal Mines Company of Alaska. His permanent address is Dedham, Mass.

DAVIS H. MORRIS, '97, is district commercial manager of the Central Union Telephone Company, 33 North Third St., Columbus, Ohio. His home address is 1763 Oak St., Columbus.

J. REESE CROCKER, '98, is with the Electric Controller and Manufacture Company, Cleveland, Ohio.

CHARLES W. BRONSON, '98, is engaged in general engineering work. His office is at 614 Colman Building, Seattle, Wash., and his home address is 2106 Queen Anne Avenue, Seattle.

T. B. SHERTZER, '00, recently with the New York Subway Contractors, is now engaged as an engineer in the construction of a dam at Uniontown, Pennsylvania.

A. HASBROUCK, '00, whose naval survey work has taken him along the Atlantic Coast from Boston to Panama, is now stationed at Fort Strong, Mass.

LEWIS H. BRITTON, '01, is manager of the general service department and efficiency department of the national quality

lamp division of the General Electric Company, Nela Park, Cleveland, Ohio.

KILBURN E. ADAMS, '02, formerly engineer in charge of mechanical and electrical installations, etc., of the Boston and Albany Railroad, is with the Edison Electric Illuminating Company of Boston as head of the incandescent lamp division. His home address is 1019 Washington St., Newtonville, Mass.

D. C. BARD, '03, reports that Harvard was well represented at the August meeting of the American Institute of Mining Engineers, in Montana. B. B. Thayer, '85, led the cheering of the Harvard contingent, composed of D. C. Bard, '03; J. M. Boutwell, '97; William Hague, '04; J. B. Gore, '00; E. H. Perry, '09; and S. S. Rogers, '09.

CHARLES W. STARK, '03, is associate editor of the *Engineering Record*, 239 West 39th St., New York City.

JOHN H. HALL, '03, who has been for several years metallurgist for the Taylor-Wharton Iron and Steel Company, High Bridge, N. J., has begun private practice at 2 Rector Street, New York City. He is consulting engineer for the Taylor-Wharton Iron and Steel Company.

RICHARD WASHBURN CHILD, '03, is with the Mississippi River Power Company, Keokuk, Iowa. This company is under the management of Stone and Webster, and Child's permanent address remains care of Stone and Webster, Boston.

THOMAS ROY CLARK, '04, of Bradford, Pa., died on April 8, at the Sherman House, Chicago, while en route to California for his health.

CHARLES GILMAN, '04, is with the C. F. Massey Company, manufacturers of reinforced concrete products, railway supplies, etc., Room 1862, 50 Church St., New York City.

JOSIAH KEELEY, A.M. '04, is assistant superintendent of mining of the West Virginia division of the Consolidation Coal Company. His headquarters are at Fairmont, West Virginia, and his home address is 1308 Seventh St., Fairmont.

GEOFFREY WILSON, Sc. '04-'06, is consulting engineer and manager of the St. Paul and Tacoma Lumber Company, Tacoma, Wash.

GEORGE S. WOODWARD, '05, superintendent of the Cambridge, Mass., plant of the American Rubber Company, was married in Cambridge, on October 9, 1912, to Miss Edith Wood.

KENNETH F. HARBOUR, '06, is with the Keuffel and Esser Company, manufacturers of drawing materials and surveying instruments, Hoboken, N. J.

A. DANA, '06, who has been in the employ of the American Bridge Company at Elmira, N. Y., has been moved to the New York City office, 30 Church Street.

KNOWER MILLS, '07, who has been for some time with the United States Forest Service, has gone from Quincy, Cal., to Nevada City, Cal.

AUSTIN B. MASON, '08, has left Big Creek, Cal., and is working on a large water power plant that is being constructed on the Missouri river. His present address is care of C. T. Main, Great Falls, Mont.

HAROLD BARNEY, '08, is with Stone and Webster, Fresno, Cal.

W. M. BIRD, '08, is acting superintendent of the Houston Electric Company, under the management of Stone and Webster, Houston, Texas.

C. T. BRODRICK, '08, is with a mining engineering company doing extensive work abroad. His address is 62 London Wall, E. C., London, England.

O. W. HARTWELL, '08, is a civil engineer in the United States Interior Department. His address is 18 Federal Building, Albany, N. Y.

GEORGE MIXTER, '08, is with the Key West Electric Company, Key West, Florida.

C. C. POPE, '08, is with the Blackstone Valley Gas and Electric Company, Pawtucket, Rhode Island.

GORTON JAMES, '08, announces the birth of a daughter, Sarah Beekman, on June 14th.

William L. Phillips, '08, M.L.A. '10, has been appointed landscape architect and first assistant in the municipal department for the Panama Canal Zone. His work will consist in laying out and building the new town of Balboa at the Pacific end of the canal and rebuilding and improving the existing towns in the zone. Phillips has been with Olmsted Brothers, landscape architects, and is now on a four months' leave of absence, studying in Europe.

The engagement of Henry C. Drown, '09, to Miss Grace E. Clark of Boston, has been announced. Drown is a mechanical engineer with the Stone and Webster Engineering Corporation, Boston.

Lee Barroll, '09, is with the Crocker-Wheeler Company, Essex Building, Newark, N. J.

Francis B. Duveneck, '09, was married on June 7th, in Boston, to Miss Josephine Whitney.

Barclay M. Higginson, '10, who was with the Cedar Rapids Manufacturing and Power Company, is with the Shawinigan Water and Power Company, Shawinigan Falls, Quebec, Canada.

Paul A. Merriam, '10, M.M.E. '12, formerly with the Wheeler Condenser and Engineering Company of Carteret, N. J., has joined the engineering staff of the Griscom Russell Company, of New York City.

Earle R. Kimball, '11, formerly with the Packard Motor Car Company of Philadelphia, is with the Boston Envelope Company, 185 Franklin St., Boston. His home address is 296 Boston Avenue, Tufts College, Mass.

Frederick S. Boyd, '12, is with William L. Mowll, '99, architect, 50 Bromfield St., Boston.

Holger W. Clausen, '12, formerly civil engineer with the United States Reclamation Service in Montana, is with the Turners Falls Company, Turners Falls, Mass.

Norman R. Sturgis, '12, is studying architecture abroad. His address is care Baring Brothers, 8 Bishopsgate Street, E. C., London, England.

WALTER S. HOOD, '12, is engaged in civil engineering in Moose Jaw, Saskatchewan, Canada.

R. BAKER, '12, is with Stone and Webster, Boston.

H. N. WITT, '12, who for the past three years has been in the United States Coast and Geodetic Survey, has returned to take mining and geology. Mr. Witt was formerly an editor of the JOURNAL.

C. H. BURRAGE, '13, is assistant in mechanical engineering in the Massachusetts Institute of Technology.

P. S. CUSHING, G. S., is in charge of construction work in connection with the enlargement of the Worcester (Mass.) plant of the Riter-Conley Company of Pittsburg.

PERSONAL NOTES

A joint paper by Professor G. C. Whipple and Melville C. Whipple on "Air Washing as a Means of Obtaining Clean Air in Buildings" was read at the International Congress of School Hygiene in Buffalo on August 27. This paper was also presented at the convention of the American Public Health Association held in Colorado Springs during September.

Professor G. C. Whipple and Professor James Ford of Harvard University have been appointed by Mayor Barry to serve on the newly organized Cambridge Sanitary Commission. The other members are Mr. Lewis M. Hastings, City Engineer, Mr. Edward W. Quinn, Superintendent of Streets, and Mr. B. H. Peirce, Medical Inspector of the Board of Health. The object of the commission is to undertake an extensive sanitary survey of the city. Professor Whipple is the Chairman of the commission, and Mr. Peirce, Secretary.

Professor Whipple has recently been investigating typhoid fever outbreaks in New York City and Philadelphia.

Professor Albert Sauveur has been awarded the Elliot Cresson Gold Medal by the Franklin Institute of Philadelphia.

Professor Sauveur has been appointed Chairman of the Iron and Steel Committee of the American Institute of Mining Engineers.

"Allotropic Transformations of Iron," by Professor Sauveur was presented at the September meeting of the Iron and Steel Institute.

The following researches are in progress in the Laboratory for Metallography, under the direction of Professor Sauveur:

"The influence of the temperature from which cooling begins upon the position of the critical points of Iron-Carbon alloys."

"Critical points of heat-treated Manganese Steel."

"Preparation and investigation of some Selenium Alloys."

"Heat treatment and properties of 'Maxari' Steel."

"The nature of Welds."

Professor Charles W. Killam of the School of Architecture has been appointed by the Governor of Massachusetts as a member of the commission to investigate the regulations now in force throughout the Commonwealth relative to the construction, alteration, and maintenance of buildings.

Dr. J. W. M. Bunker presented a paper on "Camp Sanitation" before the Squam Lake Improvement Association.

Professor A. E. Kennelly represented the U. S. Committee and the U. S. Bureau of Standards at the International Illumination Commission in Berlin, Germany, August 26 to 30, and also at the International Electrotechnical Commission, Berlin, September 1 to 5.

Professor George F. Swain has been chosen Chairman of the Boston Transit Commission to succeed the late Mr. George C. Croker.

Mr. Merl R. Wolfard and Mr. C. K. Carpenter have been appointed Instructors in Mechanical Engineering, and Mr. Charles B. Hoffman has been appointed Assistant in Electrical Engineering. The appointments are for one year from September 1, 1913.

Mr. C. L. Dawes, instructor in Electrical Engineering, has collaborated with Professor Laws, of the Massachusetts Institute of Technology, in devising a vibrating voltmeter whereby the maximum value of an irregular electro-motive force wave

may be accurately determined. The device has been patented, and the first commercial instrument, manufactured by the Leeds & Northrup Company of Philadelphia, has been recently installed on the switchboard of the Simplex Wire and Cable Company, of Cambridge, Massachusetts.

Professor Clifford, of the Electrical Engineering Department, was one of the official party of the American Society of Mechanical Engineers, on the tour of industrial Germany, made during June and early July, at the invitation of the Verein Deutscher Ingenieure. In this connection he made addresses at Berlin, Cologne and Dresden.

Mr. C. L. Dawes, instructor in Electrical Engineering, spent two months of the summer at the U. S. Naval Academy, at Annapolis, supervising the installation of certain equipment for the engineering laboratories there, and giving electrical engineering instruction to Naval officers in the Post-Graduate Department of the Academy.

Professor Clifford spent a part of the summer in Switzerland and France, in an investigation of the Thury high-voltage, direct-current system of power transmission.

Professor Clifford has been retained by the Town of Cohasset to advise in regard to power distribution and rates for electric service within the township.

Professor Clifford and Mr. Dawes are engaged in the preparation of the section on Power Transmission, for the new edition of the Standard Handbook.

Recent Publications by Harvard Men and by the Staff

"The Use of Vital Statistics in the Public Health Service." Professor G. C. Whipple. *Public Health Journal,* June, 1913.

"Studies upon Air Washing at the Springfield International Y. M. C. A. College." Mr. Melville C. Whipple. Will appear soon in the *America Physical Education Review.*

"Recommendations Concerning the Units of Force." Professor E. V. Huntington. *Bul. Soc. Prom. Eng. Educ.* June,

1913. Abstract in *Engineering News,* Aug. 28, 1913, with favorable editorial comment.

"The Physical Properties of Anhydrous Ammonia." Professor L. S. Marks and F. W. Loomis. *Trans. Am. Soc. Mech. Engrs.,* Vol. 34, pp. 782-791.

"Commission Government of Cities: Election to Specific Office vs. Election at Random." Professor L. J. Johnson. *National Municipal Review,* Oct., 1913.

"Report of the Committee on Measurements of the National Electric Light Association." A. E. Kennelly. *June Proceedings of the National Electric Light Association, pp.* 1-6. June, 1913.

Introduction to "A Color Notation," by A. H. Munsell. H. E. Clifford, Boston, George H. Ellis Co., 1913.

"Weight of Electrical Apparatus and Prime Movers." L. A. Doggett. *Electrical World,* 61:932. May 3, 1913.

"Test of an Artificial Aerial Telephone Line at a Frequency of 750 Cycles per Second." A. E. Kennelly and F. W. Lieberknecht. A.I.E.E. 32:1279-1301. June, 1913.

NOTES

Mr. M. G. Yatsevitch of Kiev, Russia, who has registered in the Mining School, has been sent to the United States by his Government for two and possibly three years for the purpose of studying American methods of instruction in Metallurgy as well as Metallurgical operations. Mr. Yatsevitch graduated from the Kiev Polytechnic Institute in 1903, served as assistant, and later as instructor in general Chemistry in the same institution, studied Physical Chemistry in Leipsig under Professor Ostwald, and has had two years' practical experience in steel works in South Russia, and in silver mines in Siberia.

The first number of Volume I of the Circular of the School for Health Officers of Harvard University and the Massachusetts Institute of Technology is ready for distribution at the Publication Office.

SUMMER COURSES IN ENGINEERING

The following graduate courses in Engineering were given during the summer of 1913:

Municipal Sanitation.
Limnology (C9L).
Road Engineering (4X).
Hydraulics (6K).
Mechanics of Structures (7L).
Elementary Mechanics and Drawing (2K).
Direct and Alternating Currents and Direct Current Machinery (16M).
Shopwork Courses (10a, 10b, 10c, 10e).

For the summer of 1913, Assistant in Electrical Engineering, G. Hall Roosevelt. Assistants at the Engineering Camp:

C. H. PAIGE, *Principal Assistant.*

Section Assistants.

H. V. BAIL	F. W. HARVEY
T. BUEL	R. C. MANSFIELD
J. J. CABOT	C. H. MARSH
L. N. CLINTON	D. A. STEEL
E. A. GRAUSTEIN	

COURSES OF STUDY

Additions and Changes

The following new courses will be given during the year:

Municipal Sanitation. (Government 31.)
For Graduates and Undergraduates specializing in Government.
Professor Whipple and Assistants.

This course will deal with the underlying principles of municipal sanitation and sanitary engineering, with reference to their administration. The topics considered will include public water supplies and water purification, the pollution of streams, methods of sewage disposal, garbage disposal, street cleaning, hygienic housing, the effect of insanitary

conditions on the public health. Attention will be given to the operation, cost, and efficiency of works rather than to construction, but important works in America and in Europe will be described.

Rural Sanitation. (Course H9P.)
For students registered in the School for Health Officers, and to other properly qualified graduate students in Harvard University.
Dr. J. W. M. Bunker.
This course deals with the principles of sanitation and hygiene as applied on the farm, at the summer resort, and at laborers' camps. Among the topics discussed are small water supplies and sewage disposal intallation, sanitation of barns and milk farms, swamp drainage, the mosquito problem, the fly problem, etc.

Demography. (Course H9N.)
For students registered in the School for Health Officers, also to graduate students in the School of Engineering and the School of Business Administration of Harvard University.
Professor G. C. Whipple and Assistants.
This is a course in vital, social, and sanitary statistics arranged especially for students who intend to enter the public health service. It will treat of the principles of statistics, population, registration, births and marriages, general death rates, corrected death rates, specific death rates, morbidity, causes of death, preparation of tables, plotting, construction of diagrams, graphical display of data, and, in general, the application of statistics to the public health service.

Elementary Bacteriology. (Course H9Q.)
For Graduate and Undergraduate Students.
Dr. J. W. M. Bunker.
This is a course for students who have never studied bacteriology, but who wish to obtain a general understanding of the relation of bacteria to the processes of nature, to chemistry,

sanitary science, and the public health. The subject-matter of the course will include the technique of isolation and identification of species, the examination of soil, water, and foods; bacteria in the industries; communicable diseases, diagnosis and methods of prevention; fermentation, sewage treatment, sludge disposal, and water purification.

Chemistry 19.

In connection with Chemistry 19, given under the direction of Dr. Jones Grinnell, a course in water analysis will be given in the Sanitary Engineering laboratory, during the second semester.

ENGINEERING *C19h.*—Physical Valuation of Public Service Corporations and its Applications. *Mon., Wed., Fri., at 12.* Professor Swain.

This course deals with the physical valuation of public service corporations, such as railroads, water works, gas and electric plants, etc., and its application in connection with rate making, taxation, capitalization, and expropriation. The principles apply to the appraisal of any industrial property, whether a public utility or not; as, for instance, the valuation of industrial plants in connection with the issuance of securities. The problem is treated in its broadest aspects, and the historical development of the subject is outlined.

A careful study is made of the various elements of the problem, such as original cost, depreciation, deferred returns, market value, going value and other intangible values, obsolescence, etc.; and reference is made to the reports of public service and other commissions dealing with this subject in various states.

BOOK REVIEW

"BUILDING CONSTRUCTION AND DRAWING," AND "BUILDING CONSTRUCTION, ADVANCED COURSE."

By Charles F. Mitchell,

(Lecturer on Building Construction to the Regent Street Polytechnic, London, Head Master of the Polytechnic High School.)

Assisted by George A. Mitchell, A. R. I. B. A.

(Published by D. Van Nostrand Co. Price, $1.50 and $2.50, respectively.)

These two books describe English building construction in materials, method, and theory.

The first book, containing 472 pages, is called elementary by the authors, and considers masonry, wooden and steel framing for floors, partitions, and roofs, joinery, lead roof covering, and quantity surveying. The subjects are treated descriptively, with very little mathematical theory, the latter being left for the advanced course.

Points of difference from American work are the emphasis upon damp-proofing and ventilating foundations, walls, and timbers, and the reliance upon brick and stout masonry instead of upon steel and reinforced concrete, inverted brick arches in foundations being a case in point. One would like a fuller discussion of corbelled stone bay windows, a construction much used in England and often copied here. Much attention is given to brickwork laid in both English and Flemish bonds, the usual methods in England. In this country the Flemish bond, when used, is simply a surface pattern, often with true headers occurring only at 6 or 8 course intervals. In England, on the other hand, the wall is bounded throughout the whole thickness with true headers, involving much cutting of bricks at corners and openings and considerably more trouble in the straight

wall. It is difficult to see any gain over the much cheaper American method of headers at intervals of 6 or 8 courses, all other bricks being stretchers. In stone masonry there is apparently much more reliance on stone cutting, arching, and bitting in places where we would use metal dowels, anchors, lintels, etc.

The use of I-shaped cast iron girders seems archaic, as does the use of rods and flats in steel truss construction. Some of the steel trusses are shown with T-shaped members connected by gussets on each side of the stem instead of members formed of two angles with a single gusset between, as with us. A strange detail is the use of a complete metal box around the end of a steel girder for fear that the girder end will weaken the supporting pier. It is difficult to understand how a steel girder solidly built into the pier can weaken it seriously, although a large wooden girder might. The subject of joinery in wood is treated in elaborate detail.

The advanced course, containing 885 pages, takes up the physical and chemical composition of materials together with the methods of manufacture in detail. Builders tools, equipment, and methods are given much more prominence than in American books. Details of construction are continued from the elementary course, with a consideration of the more elaborate work. Graphic statics and resistance of materials with applications to arches, buttresses, retaining walls, chimneys, trusses, etc., are given with many numerical examples. The steel frame and fireproof floor constructions shown have floor beams much closer together than is considered economical in the United States and they offer no helpful suggestions. In reinforced concrete there is no discussion of diagonal tension or of flat slab construction. In the consideration of wooden roof trusses one is disappointed at the very slight attention given to types of construction much used in this country as well as in England, for instance, the collar beam truss with arched rib, and the hammer beam truss. Both of these types rely in part upon rigidity of joints and stiffness of members, and also in many cases upon the lateral rigidity of the supporting walls or buttresses. They are a popular form for church trusses, and a

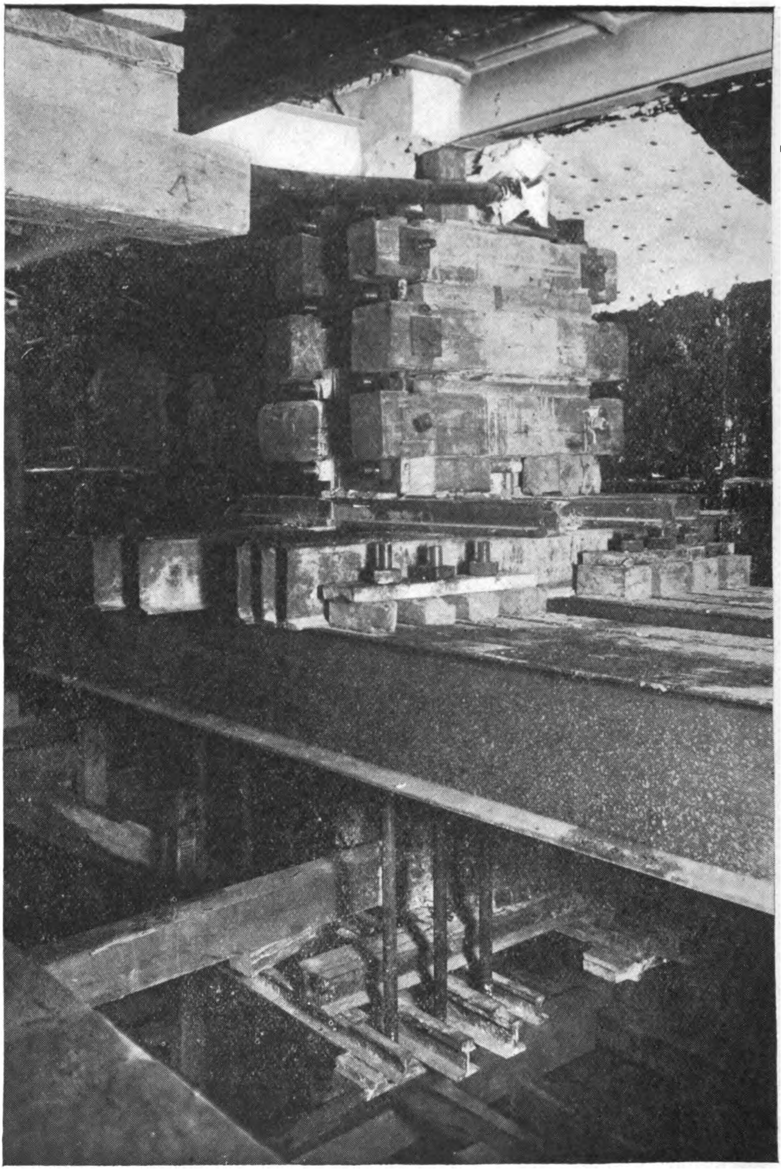
qualitative and quantitative explanation of the stresses in them is much to be desired. Stone vaulting is considered descriptively and geometrically, but with no explanation of stresses. Arched bridges, both straight and skew, are considered stresses and stereotomy being both covered. Such work in this country would be done by engineers, with the help of an architect, perhaps, in studying lines and details.

The book ends with chapters on sanitation, heating, electric work, and various examination papers, all describing methods so different from ours as to be of little value here.

The books have numerous illustrations, and resemble those on the same subject published by correspondence schools in this country. Our local materials and methods are better given by the books published here, and the theoretical discussion, which, of course, is based on the same fundamental principles in both countries, does not seem to be enough superior to make it worth while to buy the books for that alone.

While looking through these books one discovers the source of drawings and technical words found in some of the less important books and periodicals devoted to building in the United States. It seems a pity that an indolent author or editor should copy from abroad methods and nomenclature not used in this country, and thus add to the current confusion. What is needed is a treatment of the building problems of this country in terms of our methods, materials, sizes, etc., improving current practice where possible by bringing fundamental scientific knowledge to bear in the simplest, most practical way on the tremendous amount of construction that will always be done with little help from architect or engineer.

CHARLES W. KILLAM,
Assistant Professor of Architectural Construction.



One of the 210 ton columns of the Sawyer Building on temporary supports during the construction of Section A of the Dorchester Tunnel.— See page 201.

(Courtesy of Boston Transit Commission.)

HARVARD
ENGINEERING JOURNAL

A QUARTERLY

Devoted to the interests of Engineering
in Harvard University

THE OFFICIAL ORGAN OF THE ASSOCIATION
OF HARVARD ENGINEERS

VOL. XII JANUARY, 1914 NO. 4

NOTES ON THE CONSTRUCTION OF SECTION A OF THE DORCHESTER TUNNEL

PHILIP C. NASH, '11

The rapid transit system of Boston has been conservatively but steadily developing for the last twenty years. Now the system has reached a point where important additions are possible and necessary, and three of these additions—the Boylston Street Subway, the East Boston Tunnel Extension, and The Dorchester Tunnel—are under construction. The City of Boston through the Boston Transit Commission designs and builds all these subways. The Boston Elevated R. R. Co. collaborates with the Transit Commission in the general layout and design, and pays rent for the use of the subways at such a rate that the construction bonds will eventually be retired and the city will own the subways free of debt.

Of these subways perhaps the most important is the Dorchester Tunnel. Starting in Dorchester, it will relieve the congestion at the Dudley Street Station on the elevated line. Coming into the city through South Boston, it will link that section to the rapid transit system. Shooting under Fort Point Channel to the South Station, up Summer Street under the Washington Street Tunnel to the Park Street Station on the Tremont Street Subway, it will give the greatly desired quick service from all parts of greater Boston to the South Station and the surrounding district. Thus this one line will add three important items to the

transportation facilities of the city. At Park Street the tracks will run into the present Cambridge Subway, so that eventually trains will make the cross-town trip from Harvard Square, Cambridge, to Andrew Square, Dorchester, without change.

Section A of the Dorchester Tunnel is the part under Winter Street from Park Street Station to a point under the Washington Street Subway tracks. As the station connecting the two subways at this point is below Washington Street on Summer Street, it does not come into Section A.

Design.

Winter Street is about thirty-six feet wide between property lines, which gives ample room for a two-track subway, as shown on the plan and section, Figs. 1 and 2.

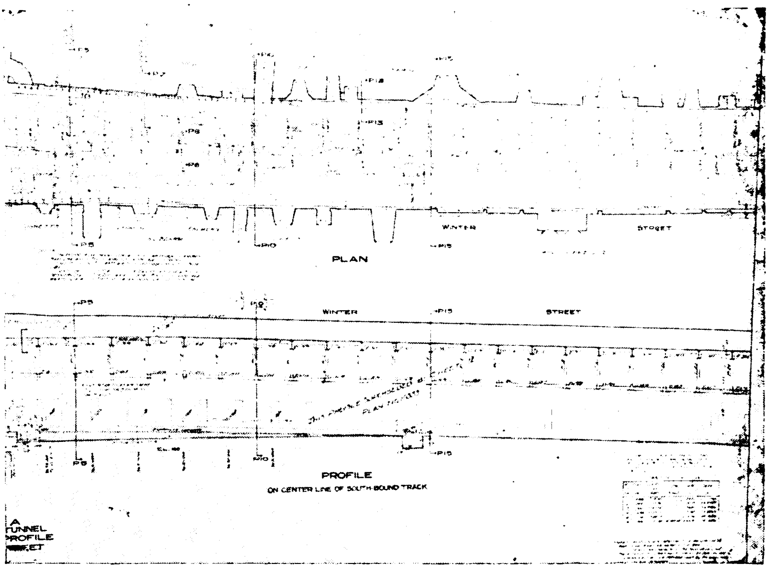


Fig. 1. Partial Plan of Section A, Dorchester Tunnel

In order to go under the Tremont Street Subway and the Washington Street Tunnel, the bottom of the new subway is at a depth of about forty feet below the street. This leaves room for

an overhead lobby above the tunnel proper, running the whole length of Winter Street, from the lobby of the Park Street Station to the lobby of the Winter Station on Washington Street.

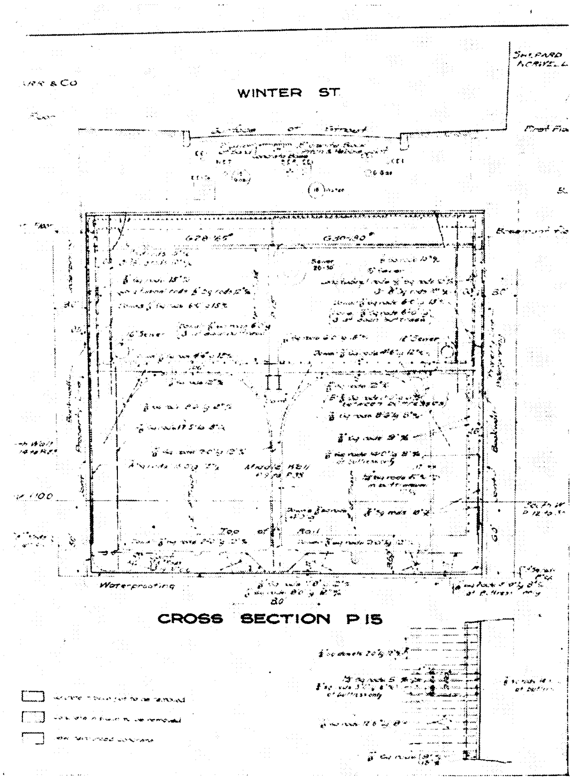


Fig. 2. Typical Cross Section of Section A, Dorchester Tunnel

Just what use will be made of this lobby has not yet been decided by the Legislature, but it would prove of great value in relieving the congestion on Winter Street if opened as a public passageway. Moreover, it was estimated fully as economical, if not even cheaper, to build this lobby than to build a heavy roof over the tunnel proper with the corresponding greater depth of backfill. This saving is evidently not in the construction itself,

as the heavy single roof would be much cheaper in concrete, steel, and labor; but is on account of the economies of a backfill six feet deep instead of twenty feet. If the contractor were bidding on a deep fill he would have to raise his excavation bid to pay for buying dirt for backfilling, or for storing part of that excavated, whereas with only six feet to backfill, the necessary quantity could be stored or obtained more easily. Moreover, with the deep fill there would be the additional expense of putting piers under the watermain and area walls in order to support them on the tunnel roof and prevent settlement.

The shield method of tunnelling would have saved some of these expenses, but it was not considered practicable under the circumstances, as the ground contained occasional waterbearing sand strata, and it would have been impossible to prevent some settlement of the buildings. Moreover, it was not feasible to get room for the large plant necessary for tunnelling construction. With all these considerations the balance was strongly in favor of the lobby above the tunnel proper.

Outside of the lobby the general scheme of design is obvious from the plans: heavy underpinning walls to carry the building loads to the level of the bottom of the subway; reinforced concrete invert, center wall and roof in the lower level; lighter walls, heavy roof beams and center columns twelve feet on centers in the upper level. The tracks are closer to the north side of the street than to the south and the north sidewall is of the usual type reinforced with vertical rods as a slab between the roof and invert. On the south side where there is more room heavy buttresses are spaced twelve feet on centers, and the sidewall is designed as a slab with horizontal reinforcement between these buttresses. This arrangement gives a very pleasing vaulted effect as one looks through the completed subway. Both sidewalls at the lobby level have the buttress and thin wall form so that it will be easy to break out panels for show windows and entrances into the store basements if such use of the lobby is eventually decided on, and the abutters so desire.

CONSTRUCTION.

The contract for construction was let on May 24, 1912 to the Coughlan & Shiels Co. Their bid was about $241,000, roughly $35,000 below their nearest competitor. The final cost of actual construction was nearly $250,000;—about $500 per foot of subway. This includes the cost of steel, concrete and other materials; the money paid the contractor under his bid; and some $20,000 worth of "extra work" done in store basements in connection with the underpinning. If the cost of engineering, interest on bonds, etc., were added to these figures the total cost would be about $600 per foot.

Fig. 3. Winter Street

(Courtesy of Boston Transit Commission)

The conditions confronting the contractor were unusually severe. Winter Street has an enormous traffic both of vehicles and pedestrians. Fig. 3 is a photograph taken looking down Winter Street on a busy Saturday afternoon.

Small entrance hatches into the "hole," seen at the right in Fig. 3, were about all that the contractor was allowed during the business days and obviously no excavation was possible. He did try to deposit concrete during the day by wheeling it in small hard-carts from the mixer at the head of the street, but found that it did not pay; and in general the day gangs merely got forms and holes ready for the concrete and excavation work of the night gangs. Even at night the quarters were very cramped. The street is too narrow to allow two derricks to work side by side, so that the work had to be carefully planned ahead to allow four derricks to work without interference.

The first big problem to be solved was the underpinning of the buildings, and this problem offered many interesting features. The Sawyer building was supported by steel columns, embedded in brick, which carry about 210 tons apiece. The "Parisian" had a foundation wall from which the stones could literally be torn out with one's fingers—and there were all conditions between these two extremes. In some cases heavy machinery, elevators, etc., coming near the piers complicated matters still more. At Shepard, Norwell's, for instance, a big engine fly-wheel came within three inches of the building pier. At Filene's two big vacuum cleaner tanks even hung out over the excavation—and there were other hindrances galore.

In all there were about fifty building piers to be underpinned. Soley & Blair Co. made a sub-bid of about $12,000 for the work of temporarily supporting them, and the work was done in excellent shape and without damage or appreciable settlement. The storekeepers on the street occasionally found doors that stuck or window sashes with the putty cracked away, which made them anxiously inquire if they were to be dumped bodily into the street. Generally, however, it was proven that the cracks were old ones, that the doors stuck because of new paint, etc.

The detailed procedure of carrying the various loads was as follows:—First, the street. The contractor excavated the whole width of the street to a depth of about eight feet in order to get room to work underneath the street bridging. The specifications call for a bridge to take a wagon load of three tons per wheel

without stressing any spruce timber above 1,000 lbs. per square inch. Allowing a generous amount for impact the stress in the stringers and cross beams might possibly have run up to 1,200 to 1,500 lbs. per square inch in the construction as shown in Fig. 5. But the heavy cross girders were of hard pine, on which 1,500 lbs. would not be excessive. In any case the bridge held up all loads required of it except for two or three breaks along towards the end of the job where second-hand timbers had been used.

When the street bridge was in place the next thing was to break out the old area walls and expose the building piers to be underpinned. To support these piers temporarily, I beams were put lengthwise of the street on each side of the pier in question, the load being carried to the main I beams by means of needle beams. In many cases the piers were composed of such loose stuff that there was danger of their crumbling if handled very much. Where this happened the pier was clamped (see Fig. 7) and the needle beams put across under pier and clamps. It was rather a delicate job to cut out part of the pier, slip in the needle

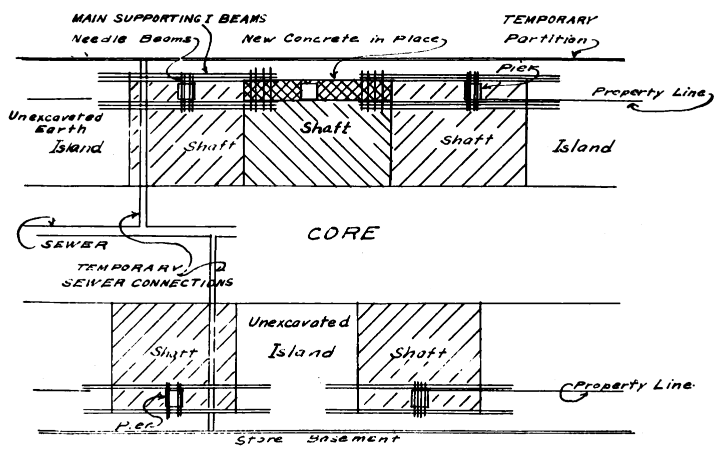


Fig. 4. Plan of Underpinning, Section A, Dorchester Tunnel

beam, transfer the load to this by means of wedges, then cut out a little more of the pier, and so on till all the load was on the beams. It was impossible to effect this transfer without slight

settlement of the pier. To counteract this, jacks were put under the ends of the main longitudinal I beams, and the settlement taken up on the jacks. When the pier was safely supported on the beams a trench was excavated to final grade, some forty feet below the street, the ends of the beams resting on the solid ground, and leaving the pier hanging directly over the hole. The scheme is shown in the sketches, Figs. 4 and 5.

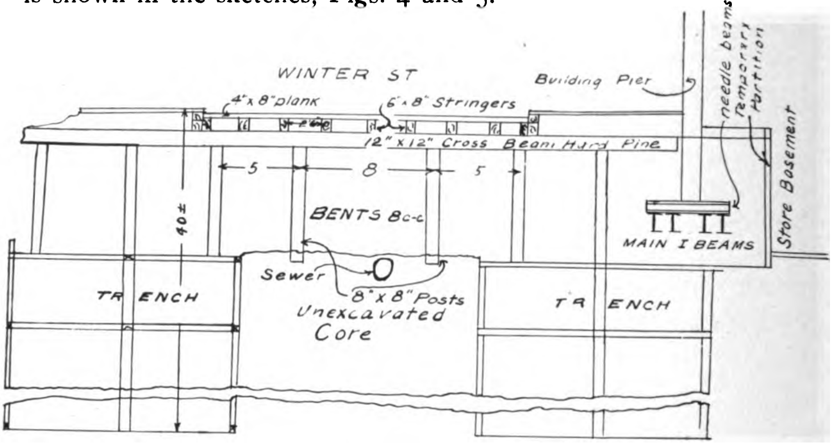


Fig. 5. Underpinning Construction, Section A, Dorchester Tunnel

The shafts were about 14 feet wide crosswise of the street. The length of each hole was determined by the load on the pier, since the underpinning wall, usually 2ft. 6in. thick, had to be long enough as a monolith to distribute the column load to the earth at about four tons per square foot.

The underpinning walls of plain concrete were carried up to the lobby floor with this required length, but above the lobby floor piers only large enough to take the column footings were built, and cinder concrete was placed in the holes between the piers. The piers, or "chimneys" as they came to be called, were carried to within about a foot of the supporting I beams and allowed to set from two to ten days, depending on the unit load to be carried. Then steel plates and wedges were put in, and on top of these the piers were caught up, one part at a time by brick-work.

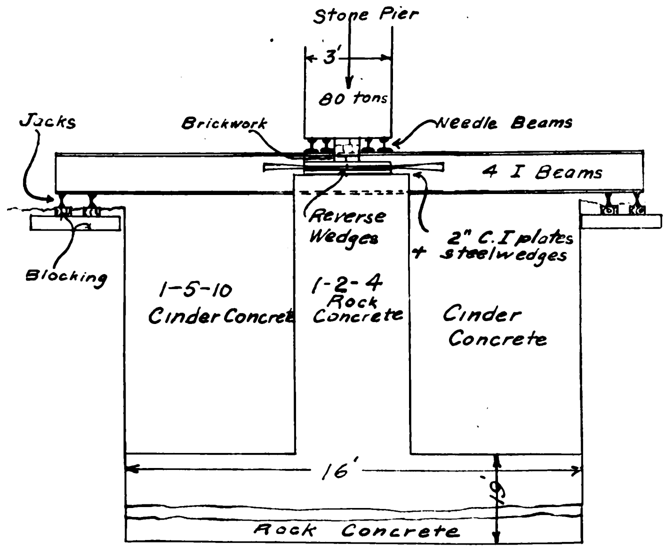


Fig. 6. Underpinning Details, Section A, Dorchester Tunnel

Fig. 6 shows a typical pier partly caught up. Reverse steel wedges were put between the cast iron plates so that when the outside wedges were driven up there would be practically a uniform bearing on the plates. Before all the needle beams were removed the wedges were driven up hard to counteract any slight settlement of the pier. When finally firm all the load was removed from the longitudinal I beams and they were slid along the street to take the next pier on the program.

The frontispiece shows the detailed method of holding one of the 210 ton columns on the Sawyer Building.

Eight 20 inch I beams spanning about twenty-five feet were used to carry the load. Cross beams were put underneath the bed plate and carried by hangers from the main beams. In addition the column was heavily clamped and needle beams put under the clamps.

The black background in the photograph is the temporary partition between the store basement and the subway. These partitions were of ⅞ inch matched boards, covered on the outside

with asbestos paper as a precaution against fire, and then a layer of asphalt put on to make them, as far as practicable, dust and moisture proof. This practice is in marked contrast with that of the New York subways, where similar partitions are built of hollow tile and mortar.

Noting again Fig. 4, it is interesting to compare the method of underpinning actually used with a tentative scheme proposed by another firm bidding on the job. This was to hold the building piers by transverse beams, one end in the store cellar, the other on the central core. The big advantage of this method over the other, is that there is no limit to the length of trench that can be sunk under the pier. As actually done, this length had to be kept comparatively small so as to give as short a span as practicable for the longitudinal I beams. The disadvantages are,—first that the cross beams would project farther into the cellar, and the contractor had to pay $.02 per square foot per day for space occupied in the basements; and second that the roadway on the core would be obstructed with the blocking, etc. But perhaps another and better roadway could have been built on the bracing to take its place. Anyhow it brings up the old adage that "there are more ways of killing a cat than choking her with cream"; and that it pays well to spend time and effort in finding the cheapest and quickest way out of a difficulty, since both economy and speed mean money to the contractor.

There is one other bit of supporting that should be mentioned—that of the various public service mains, especially the sixteen-inch watermain. This watermain was one of the contractor's pet worries. He kept a man on it all the time to guard against settlement, as he well knew the almost inconceivable amount of damage that would be done if it should break. But it did not break, and is now firmly supported on wooden cushions and brick piers on the lobby roof. The big central brick sewer (see Fig. 2) also gave some trouble. The contractor intended to leave it undisturbed in the core until he was ready to take out the core, but uneven settlement caused the sewer to break in places. The core then became saturated with water and threat-

ened to cave, forcing him to dig up large stretches and put in a temporary wooden box to carry the sewage.

Problems as interesting as those of the underpinning arose at every stage of the work, but can be only briefly mentioned in the present discussion.

When a reasonably long section of underpinning wall was finished, a six-inch wall was built outside of it. The reason for this is to give ample protection to the waterproofing, if the underpinning wall should ever be torn down to "rebuild greater." The idea is a good one; the need for such a protective coat has appeared on the older subways where new high buildings have been built adjacent to them, but the wall itself was a nuisance to build. It was so thin that the concrete could not be shot directly into place from the street, but had to be delivered to a staging and carefully shovelled in. The forms were brought up only about four feet ahead of the concrete, so that it could be well spaded and easily inspected.

The next operation was the waterproofing of the sidewalls and part of the invert. The waterproofing seems at first sight a very easy part of the whole work. The materials consisted of two layers of "minwax" asphalted cloth alternated with three layers of asphalt mopped on while hot, the principal requisite being that there should be no holes in the finished coat. But oh, the trials and tribulations of the foreman (Hot Tar Harry, as he came to be called), before the desired end was accomplished! If he were working down on the invert it seemed certain either that the sewer would leak or that somebody would be washing forms up overhead with the hose. Even if he were working on the roof he could not escape the water:—it would either rain or the watering cart would go by overhead and the water trickle down through the bridge. Also Harry was the unluckiest man on the job in getting hurt. One day while he was climbing to the surface a horse fell into the hatch and met Harry halfway. Luckily Harry was not seriously hurt but it was distinctly more quiet and subdued around the waterproofing gang for a few days.

The hardest part of the waterproofing was on the invert, both because of water and the shifting of bracing. A four inch mat of concrete was placed directly on the earth and the waterproofing was laid on that. Of course the posts holding the street came down to the invert and the lowest section had to be shifted so that no break should occur in the waterproofing coat. To accomplish this a little patch of waterproofing was put down near the post in question and a new post put on this patch to take the load from the old post. Then the old post was knocked out and the waterproofing made continuous. Some care had to be exercised to see that a laborer trying to act as a bracer did not knock out post No. 1 before he had post No. 2 in place. If this had ever occurred the results would have been more serious even than if "old Mike," who lowered the pails, should drop the boiling tar on the men beneath.

The other big waterproofing hindrance was the water. On this job the contractor used no system of underdrainage. Not a great deal of water was encountered, but what there was, had to flow down over the invert to the sump at the lower end of the job. To get the invert dry enough for waterproofing a little dry cement channel was built for the water, and then sawdust sprinkled liberally on the 4 inch mat, absorbed the moisture and was swept up just in advance of the waterproofing. On the walls the work was easier, as there was no water to bother, and the only problem was the shifting of the side braces. The men gradually became very expert wielding their rather clumsy mops, learning to throw the asphalt into the sharp corners, and in general to get a smooth, tight surface. At present there are very few leaks in the subway, showing that a satisfactory job has been obtained.

After the sidewalls and parts of the invert were waterproofed three operations were carried on more or less simultaneously. These were:

(1) Excavating the core of earth left in the center of the street and replacing the old egg-shaped sewer by a temporary wooden box.

(2) Building the lobby walls.

(3) Laying the permanent new sewers.

These sewers were inside the tunnel lobby and great care was taken to make them leak-proof. The house connections had to be laid in place before the sewer itself was laid. This was because of the necessity of having a firm, tight job of waterproofing around these connections. The pipes extended into the lobby so as to fit accurately into the branches of the sewer itself when that should be laid later. As there could be absolutely no play in the connection, it was rather a delicate matter to be sure of a watertight joint, but the desired result was accomplished in every case.

After the core was excavated it was comparatively quick work to join the two side inverts and put in the center wall. At first the forms for the center wall were braced from the sidewalls, but in almost every case the forms spread more or less and it was found necessary to bolt the two side forms together. Then the center column footings were set, the columns carefully plumbed, and the heavy 28 and 30 inch roof beams set in place.

It was interesting work on a cold Sunday morning in February to pick up with a derrick, one of these girders weighing a ton and a half, nurse it down among the network of braces and pipes just under the bridge, and finally place it true on the buttress and column. There were very few accidents, however, on this heavy steel work. The only exception was when a heavy column slipped in the lowering chains and fell to the bottom, fortunately without killing anyone.

Up to the time when the roof beams were set, practically the whole street load was carried down to the invert some forty feet. Such long columns were not pleasant to handle, especially as so much rebracing was necessary for the waterproofing, concrete forms, etc. So the contractor was glad to see the street load transferred to the solid roof beams only seven feet below.

As soon as this was done, all the old bracing was knocked down and the roof of the tunnel proper, "the double barrelled arch," was turned. This formed the lobby floor slab and almost before it was hard enough not to show footprints, the forms would be started for the lobby roof.

When the roof was concreted the next job was to pick up the waterproofing lap on the sidewall, done some two months before, and waterproof the roof. Then came the 3 inch protective layer of concrete on the roof, the building and waterproofing of the area walls and the laying of the new gas, telephone, and Edison services, and finally the backfilling.

This work went very smoothly except that during a heavy rain on February 22, a load of backfill broke a waterservice pipe. In five minutes all the backfilling and repaving of two days was a wreck, and two more pipes were broken before the main could be shut down. After that more care was used in dumping the heavy backfill onto the light service pipes.

Finally, after the backfill had settled a few months, the finishing touches were added, the street repaved, the granolithic sidewalks replaced, the store basements restored to their former condition, and the job was done.

The work was under the supervision of the Boston Transit Commission, Mr. G. D. Emerson being engineer in charge. For the contractors Mr. J. J. Coughlan took the general supervision and laying out of the work, with day and night superintendents under him. The construction was finished in April, 1913, and at present work is progressing on the next section under Summer Street.

THE CATSKILL WATER SUPPLY OF THE CITY OF NEW YORK

CHARLES S. BRISK, G. S. 1911-1913

At the present time there are but two engineering enterprises the cost of which exceeds that of the Catskill Water Supply of the City of New York, and only one, the Panama Canal, has required a greater number of men for its construction. It is the opinion of many prominent engineers that, taking into account the difficulties involved, the Catskill project is the most gigantic undertaking of recent years.

A few words regarding New York City, its location, size, and the general conditions prevalent therein, are quite necessary for a clear comprehension of the work in hand.

The City of New York consists of five boroughs: Manhattan, the original city of New York; Bronx, formerly a part of Westchester County; Brooklyn and Queens on Long Island; and Richmond (Staten Island), geographically a part of the State of New Jersey, and separated from Manhattan by New York Harbor, a distance of five miles. Each of these boroughs is co-extensive with one of the counties of the State of New York, and all of them must be included in any scheme of water supply. A map of the city is shown on the lower end of the accompanying diagram of the aqueduct, page 210.

The total area of the greater city is 329 square miles, and the population as follows: in 1900, 3,400,000; in 1910, 4,800,000, and estimated in 1913, 5,250,000. The city is growing therefore at the rate of nearly 3% a year. In other words, every year the city grows by a population equal to that of Worcester, Mass., and every five years by a population equal in size to that of Boston. As estimated by Mr. Freeman, by 1930 New York will contain more than 7,000,000 people. Since the quantity of water consumed varies directly with the number of persons supplied, it must also be remembered that New York is the business center

for all the territory within a radius of many miles. From the top of the Woolworth Building a view can be had over country in which more than one-tenth of the people of the whole United States live.

At present the water of the city is supplied from many different sources. The principal one is that of the Croton watershed, now developed to its fullest capacity and supplying the boroughs of Manhattan and the Bronx. Brooklyn and Queens are supplied from surface and ground waters of Long Island, while Richmond obtains its water from artesian wells.

The water consumption was, in 1905, 450 millions of gallons per day, and in 1913, 550 millions of gallons per day. This meant that the available supply was drawn on to a dangerous extent, as may be seen by considering the statistics of the Croton Supply.

Area of watershed	360 square miles
Total storage	110,000 millions of gallons
Safe yield, daily	280 millions of gallons
Maximum draft	340 millions of gallons

In Brooklyn and Queens the quest for more water led to the procuring of many questionable sources. These alarming conditions were recognized as early as 1899 in a report rendered by John R. Freeman, and again in 1900 in "An Inquiry Relating to Water Supply of the City of New York" published by the Merchants' Association in 1900, and finally in the Burr-Hering-Freeman report completed in 1904, wherein a solemn note of warning was sounded. New York City was in danger of an acute water famine, it was stated, in the event of two successive dry years. It was at this time that steps were taken for the additional water supply and the Catskill plan was conceived.

At this point it would be well to consider the location of New York. The city is situated at the mouth of the Hudson River. To the east lies Long Island and the states of Connecticut and Massachusetts. It must be remembered that interstate streams are not available as a source of water supply. To the west is New Jersey, and to the south is the Atlantic Ocean. Therefore, the

only available sources lie to the north, and are limited by the fact that the region to the east of the Hudson is of low elevation and its streams are of questionable character. Other sources spoken of were:

(1) Lake George, which has an abnormally small watershed.

(2) Lake Ontario, which is impossible on account of its great distance (400 miles) and complications arising from the fact that this is an international lake.

(3) The Housatonic River,—interstate stream.

(4) Dutchess County,—prohibited by legislative enactment.

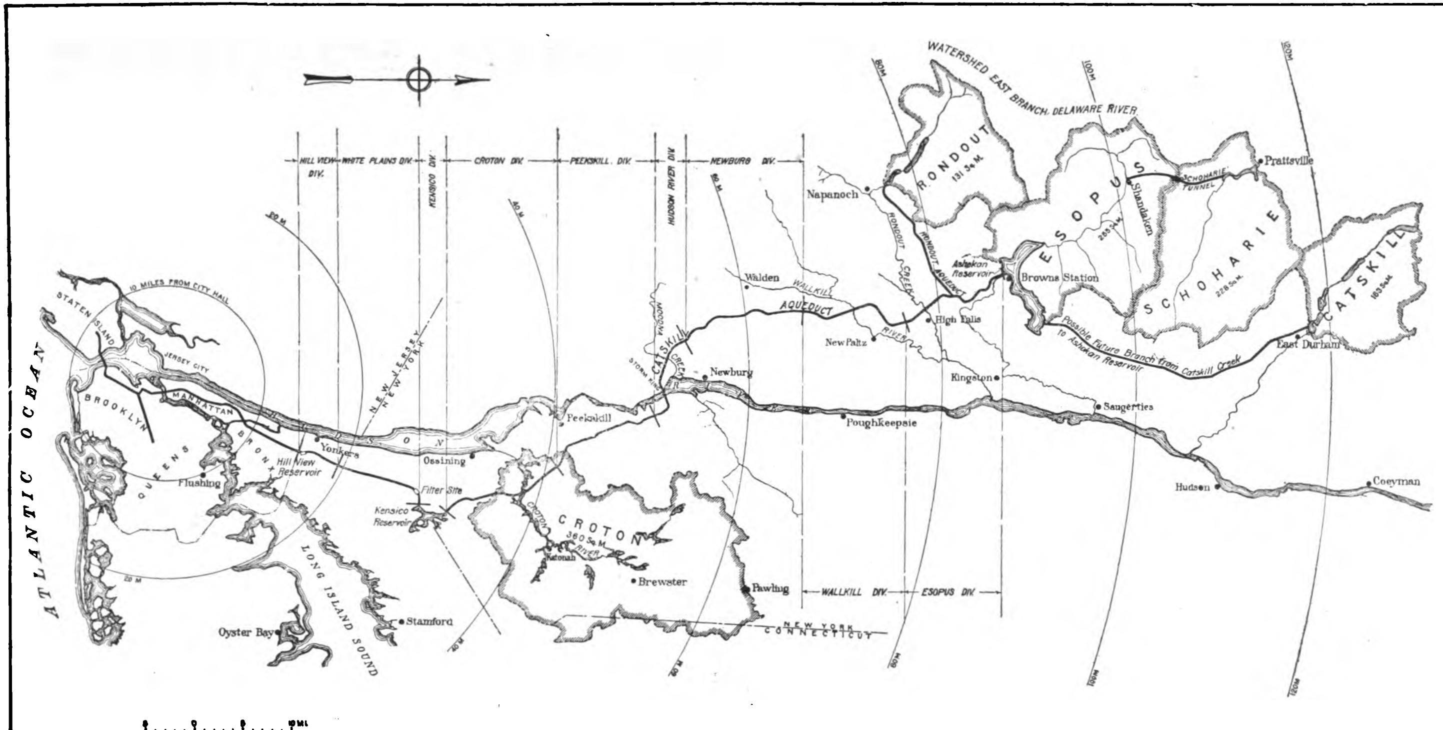
(5) Artesian wells. With the exception of certain portions of Long Island, there is almost no artesian capacity, and on Manhattan Island and the main land the crystalline rocks make such development useless.

(6) Hudson River,—an estuary of the sea, with brackish water of a very impure quality, wholly unfit for domestic purposes.

Moreover, the size of the watershed necessary eliminated all but very few streams. Using Mr. Freeman's estimate of 7,000,000 population in 1930, with a per capita consumption of 150 gallons daily, we see that a supply of 1,100 million gallons per day will be needed. The most that could be expected of the existing supplies was 300 million gallons daily from the Croton shed; and a possible yield of 250 million gallons daily from developed Long Island sources. This left 550 million gallons daily to be secured, which meant, considering economical storage and a run-off of one cubic foot per second per square mile of watershed, a required tributary area of over 800 square miles.

This requirement, the quality of the water to be secured, and the necessary elevations for a gravity supply were the governing conditions leading to the development of the Catskill region.

From a sanitary standpoint the watersheds of the Catskill mountains are all that could be desired. They are mountainous, with steep slopes and heavily wooded hillsides. With the exception of a very few places in summer-time, they are but sparsely populated. A map of the total ultimate development is shown on the accompanying cut, and includes the four principal streams,



CATSKILL WATERSHEDS AND AQUEDUCT

the Esopus, Rondout, Catskill and Schoharie Creeks. At the present time only the Esopus Creek is being put to use.

Following are the main figures relating to the watersheds:

Stream	Area of watershed	Estimated safe yield
Esopus	255 square miles	250 Million Gallons Daily
Rondout	176 " "	157 " " "
Schoharie ...	228 " "	200 " " "
Catskill	224 " "	160 " " "
Total	883 " "	767 " " "

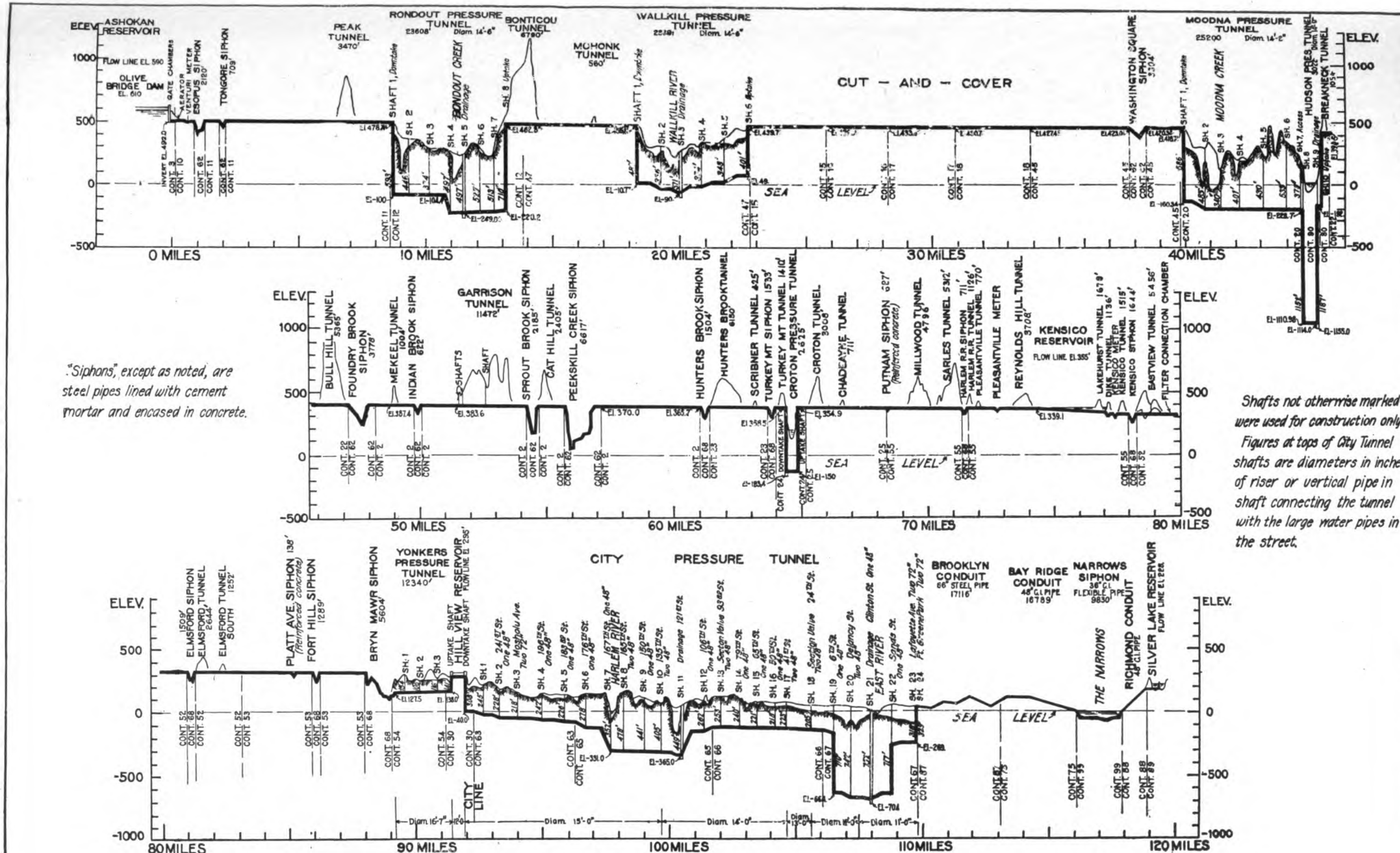
As shown on the map, the various sheds are to be connected by branch aqueducts leading into the Ashokan Reservoir, the main storage basin formed by the construction of the great Ashokan dam. From under this dam the water is conducted by aqueduct to the west of the Hudson River to Storm King Mountain near West Point, where it passes under the Hudson, and then down on the east of the Hudson to an emergency reservoir at Kensico. From Kensico the water passes to the Hill View distributing reservoir, just north of the city line, whence it is distributed throughout the city by means of pressure tunnels and delivery pipes, the line finally ending at Silver Lake, the terminal reservoir on Staten Island, 120 miles from the Ashokan Dam.

The Ashokan Reservoir is formed by the Oliver Bridge Dam and the Beaver and Hurley dikes. A concrete waste weir with a spillway 1000 feet long takes care of the flood flows of Esopus Creek. It is cut in half by a dividing weir about a mile and a half from the southwesterly end, making two independent basins. Some idea of the size of the Ashokan Reservoir may be had when we consider that the area covered by this basin is more than twice the area of the city of Cambridge, and that the water contained therein could submerge the entire city of Boston to a depth of 40 feet.

STATISTICS OF ASHOKAN AND KENSICO RESERVOIRS.

	Ashokan.	Kensico.
Capacity, total	132,000,000,000 gallons	38,000,000,000 gallons
Capacity, available	128,000,000,000 gallons	29,000,000,000 gallons
Water surface	12.8 sq. mi. = 8,180 acres	2,218 acres
Land acquired	15,222 acres	4,500 acres
Elevation of water (full reservoir) above tide..	590 feet	355 feet
Elevation of tops of dams, above tide.....	610 feet	370 feet
Length of reservoir	12 miles	4 miles
Length of shore line	40 miles	40 miles
Length of dams & dikes	5½ miles	3,300 feet
Main dam:		
Length	4,650 feet	1,843 feet
Height	220 feet	300 feet
Thickness at base	190 feet	230 feet
Thickness at top......	23 feet	28 feet
Width of reservoir, maximum	3 miles	3 miles
Average	1 mile	1 mile
Depth of reservoir, maximum	190 feet	155 feet
Average	50 feet	100 feet
Villages to be submerged	7	....
Permanent population of villages in 1905	2,000	500
Cemeteries removed	32	none
Bodies re-interred......	2,800	few
Railroad being relocated.	11 miles	none
Highways to be discontinued	64 miles	14 miles
Highways to be built ...	40 miles	9 miles
Bridges to be built	10	4
Earth and rock to be excavated	2,936,000 cu. yds.	2,486,000 cu. yds.
Embankment to be placed	8,069,000 cu. yds.	2,003,000 cu. yds.
Masonry to be placed ...	984,000 cu. yds.	1,286,000 cu. yds.
Cement to be used	1,187,000 bbls.	1,224,000 bbls.
Maximum number of men employed	3,000	1,000

The Catskill Aqueduct extends from the upper gate chamber at Ashokan Reservoir to the equalizing reservoir at Hill View, a distance of 92.3 miles, and thence 27 miles to Silver Lake Reservoir on Staten Island. The determination of the final location necessitated the careful investigation and study of the cost of the structure and of its ultimate security, including with other factors topography, geology, and the accessibility of construction material, especially of concrete aggregates.



CATSKILL AQUEDUCT, PROFILE FROM ASHOKAN RESERVOIR TO SILVER LAKE RESERVOIR

B.W.S. 751

There are four principal types of construction which, in the order of cost per lineal foot, stand as follows: Cut and Cover, Grade Tunnel, Pressure Tunnel, and Steel Pipe Siphon. On account of its relative cheapness, as much of the line as possible is of cut and cover concrete aqueduct. Likewise, whenever the geological conditions are suitable, valleys are crossed by pressure tunnels sunk deep into the rock, this type of aqueduct being cheaper than siphons of steel pipe laid at or near the surface. The total fall available for producing flow in the aqueduct is apportioned between the different types of construction in inverse ratio to their cost per lineal foot, in order that the cost of the whole structure may be as small as possible. Thus, the greater fall or slope per unit length is given the most expensive type, the steel pipe siphons, in order that the size and hence the cost may be kept as small as possible. In like manner each type has been given a slope consistent with its cost, the highest gradient falling to the cut and cover construction, as it is the cheapest.

As finally located, the line crosses by pressure tunnel three principal valleys west of the Hudson River, viz., those of Rondout Creek, Wallkill River, and Moodna Creek. It crosses under the Hudson River at Storm King and Break Neck Mountains, and descends beneath Croton Lake on the east side of the Hudson. At the lower end there is another notable pressure tunnel, the Yonkers siphon, about two miles long, just north of Hill View Reservoir. In all there are about 18 miles of pressure tunnel north of the city. There is a total of 6 miles of steel pipe siphons, the longest single siphons of this type being the Bryn Mawr, Peekskill Creek, and Foundry Brook, all east of the Hudson. Grade tunnels of an aggregate length of 14 miles pass through mountains and ridges. There are 24 of these tunnels. Notable in point of length are Hunter's Brook, Bonticou, and Garrison, the last being the longest (11,430 feet).

Cut and Cover Aqueduct.

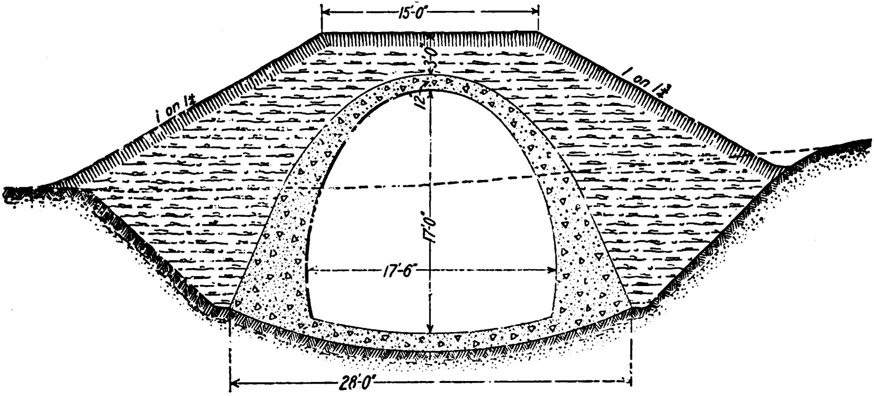
Except for a few comparatively short stretches located below the hydraulic gradient, the masonry aqueduct, built in open trench or on embankment, is of plain concrete, covered with an

embankment of earth or of earth and rock. The masonry section, constructed in loose earth, is of the conventional "horse shoe" type, 17 feet 6 inches wide, by 17 feet high. The arch is 12 inches thick at the crown, and increases in thickness to a maximum of 66 inches at the bottom, these thicknesses being uniform throughout the length. But the invert, usually 16 inches thick, is changed to meet conditions of loading, or of the foundations, by making it thicker or by spreading the base, or both, and by inserting steel rods in some places, enabling it to safely distribute loading due to possible nonconformity in the foundation. The embankment is generally 3 feet in depth over the crown of the arch with a top level 15 feet wide, and with slopes of 1 in 1¾ to the natural surface. The cross section of the various types are shown on accompanying sketch.

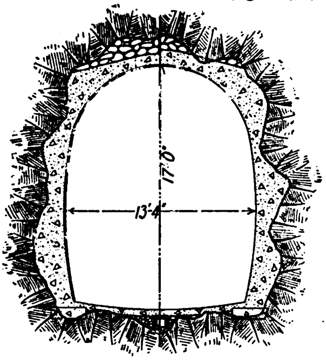
In order to obtain as firm and unyielding a foundation as possible the line is located to avoid construction on embankment, but in a few comparatively short stretches economy dictated a location on foundation embankment in crossing narrow gullies, which could not be done in any other way. Embankments under the aqueduct are compacted with the greatest care in three-inch layers thoroughly watered and rolled. The side walls are splayed to give broad foundations to reduce the unit pressure.

In sound rock and in sufficiently compact earth the trench is excavated to steep side slopes and the concrete in the lower portions of the side walls deposited directly against the side of the trench. In compact earth the side wall masonry is 20 inches thick as a minimum, and in rock has an average thickness of about 20 inches with a minimum of 12 inches to the farthest projecting point of rocks.

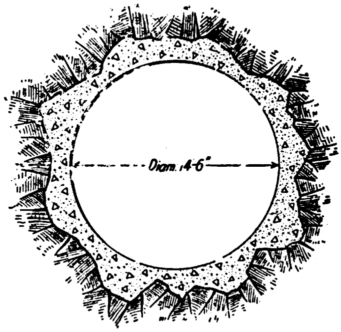
The masonry section as designed was carefully investigated as to stability under all possible conditions of loading which could be conceived. In dry, loose earth the masonry section is stable with the aqueduct full of water without the aid of the surrounding embankment, and also for water rising from some unusual condition above the inside of the top. The line intersects many roads, so the section with three feet of cover over the arch



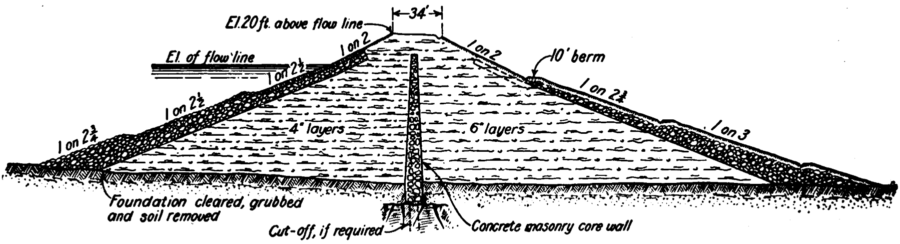
CUT AND COVER AQUEDUCT



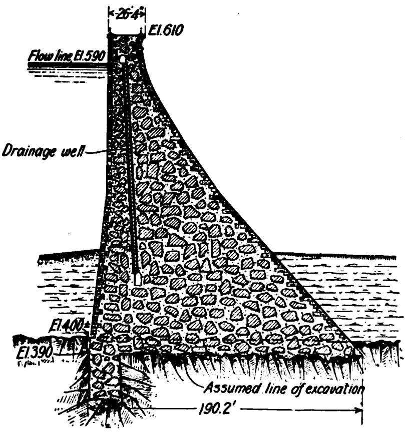
GRADE TUNNEL



PRESSURE TUNNEL

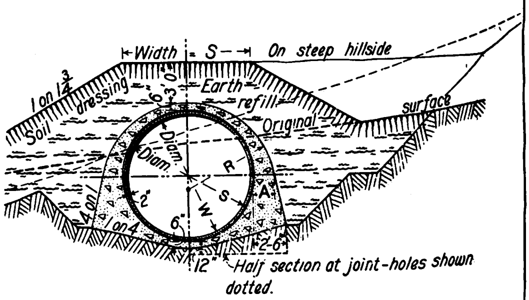


TYPICAL SECTION OF DIKE



OLIVE BRIDGE DAM

MAXIMUM MASONRY SECTION



STEEL PIPE SIPHON

will support a 12 ton roller. A fill of 14 feet may safely be made with a plain invert of the usual thickness (16 inches), but for greater fills the invert will be strengthened by building steel rods into the concrete. Whenever the ground water adjacent to the structure is more than 9 feet above the invert this portion is made thicker to withstand the upward water pressure when the aqueduct is empty. The sections as designed were examined as to buoyancy and found to be secure against flotation in a flooded trench under any conditions which can reasonably be imagined as occurring during construction.

The invert is built in 15 foot lengths with concrete key blocks under each joint. The side walls and arch are constructed in such lengths that the concrete can be placed by continuous operation. Between portions a joint composed of a concrete tongue and groove, or of a metal strip built into the concrete, provides for expansion and contraction due to temperature changes and prevents loss of water. In the aqueduct so far built these sections average about 45 feet, though they vary from a minimum of 15 feet to a maximum of 75 feet.

The method of construction can best be illustrated by a description of some of the work on the line of the aqueduct.

The most economical method is to excavate, concrete, and backfill simultaneously. The top soil is first carefully removed and stored along the trench to be later used as a surface dressing for the embankment. Standard gauge tracks are laid on each side of the line so that while one is being used for hauling excavation the other is used for cars conveying concrete. Steam shovels are used except for the last six inches. When rock is encountered, steam drills working ahead of the shovels enable them to work continuously. Side-dump cars carry the excavated material back and deposit it on the completed portion of the aqueduct where tracks are laid on an earth cushion, the trench excavation being about 150 yards ahead of the concrete work.

As the cuts and fills balance very closely with the exception of a few unavoidably deep cuts, all the excavated material is usually needed for the embankment. Whenever the concrete

work is delayed the method of spoil is to dump the cars ahead of the line of the shovels, to be removed when the shovels reach this point. In this manner, work can be continued without interruption.

After the shovel has completed the work, men prepare the subgrade with picks and shovels. The material is removed by buckets operated by a locomotive crane which afterwards handles the concrete for the key block and invert work. The crane also sets the forms and pours the concrete for the aqueduct structure. Whenever necessary sub-drains are built before the placing of the key-blocks, the first step in the concreting work.

The key blocks are placed every 15 feet and are 16 inches wide, 8 inches deep in earth, and 4 inches in rock. Grade points are given and the profile forms set accordingly. They consist of two steel web-plates, $\frac{3}{16}$ inches thick, with angle irons riveted to the outside face and curved in the invert profiles. The forms are kept from spreading by means of large steel staples passing through the angles or flanges at the center and at each end. Concrete is placed by hand with shovels, the most economical way. After several key-blocks have been placed the invert is formed. This is placed in 15 foot lengths between alternate pairs of key-blocks. Forms similar in design to those for the key-blocks are placed upon the key-blocks and wedged to proper grade. Concrete is now placed by means of a movable derrick and spread by hand. Then a 3 inch smooth, steel shaft is rolled from side to side, bearing on the steel forms for the purpose of screeding and giving a finished surface to the invert. A number of alternate sections having been completed, the intervening spaces are filled with concrete and screeding is done by aid of the finished sections. Expansion and contraction due to changes of temperature are thus satisfactorily taken care of at the joint of each 15 foot block.

Owing to the size of the aqueduct, and the necessity for an accurate cross section and smooth interior surface, the design and construction of a proper form presented many problems of difficulty. Their solution presents one of the most interesting constructional features of the entire work. These problems

were solved by the Blaw Collapsible Steel Centering Company, of Pittsburgh, Pa. Heretofore the larger concrete conduits have been constructed with wood forms covered with sheet metal, but, in spite of the utmost care, these forms would generally twist out of shape, and the cost of moving and maintenance would amount to a large sum. Therefore the steel form was the only one to be considered for this work.

Many limitations, imposed by the character of the work, and by the requirements of the contractor, made the design of the steel forms complex. The turning of curves in the aqueduct with 5 foot and 15 foot tangents of the invert complicated the construction and handling of the forms. A form designed to take care of the curves as well as the straight work without additional filling pieces or sliding plates appealed to the contractor from an economical standpoint, and to the engineer as lessening the joints in the finished work and presenting a better method of keeping the expansion joints of the crown over the joints of the invert.

The curves of the aqueduct are, with but few exceptions, of 200 foot radii. This uniformity of curvature made the design of the forms a simple proposition, as, instead of making the 5 foot sections with ends parallel, they are made tapering. In plan they are not unlike a trapezoid with equal sloping sides. When the sections are assembled with the long sides adjacent the forms take the curve; when the long and short sides are assembled the forms are suited to straight work. In order to accomplish this reversing of the sections in a rapid manner, the traveller, on which the forms are collapsed and moved, is equipped with a turn-table.

The City Aqueduct.

The Hill View reservoir is located in the city of Yonkers, just north of the New York line, and 15 miles south of the Kensico reservoir. Its purpose is to equalize the difference between the use of the water in the city as it varies from hour to hour and the steady flow in the aqueduct. It will also furnish large quantities of water upon immediate demand, as in a great conflagration. Its capacity is 900,000,000 gallons, and its con-

struction required the excavation of 3,200,000 cubic yards of earth.

From the Hill View reservoir Catskill water will be delivered to the five boroughs by a circular tunnel in solid rock, reducing in diameter from 15 feet to 11 feet. From two terminal shafts in Brooklyn steel and iron pipe lines will extend into Queens and Richmond. A cast-iron pipe resting on the harbor bottom will cross the Narrows to the Silver Lake reservoir on Staten Island, which holds 4,000,000 gallons. The total length of this delivery system is over 34 miles. The requirement that the tunnel be in good material, the necessity of avoiding interference with streets, buildings, subway, sewers and pipes, and the requirement that there should be 150 feet of good rock above the center line of the tunnel in order to withstand the hydrostatic pressure made it necessary that the depth of the tunnel should vary from 200 to 750 feet below the level of the street. The tunnel is being constructed from 24 shafts about 4,000 feet apart, located in parks and other places where they interfere very little with traffic. Through these shafts, also, the water will be delivered into existing and additional pipes. Tunnels and shafts are being lined with concrete.

The work of construction has been in progress for about seven years, and the aqueduct is practically complete up to the city line. About 95% of the work in the city tunnels is finished, and it is expected that within a year the people of New York City will be drinking water from the Catskill streams.

Acknowedgment.

The writer wishes to express his appreciation to the engineers of the Board of Water Supply for their courtesy in permitting the inspection of the aqueduct at various points, and especially to Mr. Flynn, through whose kindness the accompanying cuts were obtained.

SCIENTIFIC MANAGEMENT A VIEWPOINT

EDWARD L. LINCOLN, '08

Scientific Management has been kept in the public eye quite constantly for the past few years by the far-reaching claims of its advocates on the one hand, and the condemnations of its opponents on the other. Far be it from me to indulge in an exposition of this absorbing science, when such excellent and interesting books have been written on it as Mr. Frederick W. Taylor's "The Principles of Scientific Management," and Mr. Frank B. Gilbreth's "Primer of Scientific Management."* I would, however, like to give a few first impressions, looking at it more from the point of view of an outsider, a layman who has been fortunate enough to be allowed to have an inside look at some of its workings.

Scientific management is an ideal state, a state to be striven for, and attained, if at all, only after diligent and strenuous effort. It is, when attained, a cure for many of our economic ills, some go so far as to say, a panacea for such ills. No one can doubt that if all the men in a plant got together, pooled their combined skill, and from the resulting knowledge tabulated a standard method, and if all worked under careful supervision and instruction along this best method, the product would be greater, and the employer would be able, while making greater profit, to pay higher wages for a shorter working day. That is practically what scientific management amounts to. The time and motion studies are the pooling of skill, unconscious though it may be; and the planning department and "bosses" are the supervision and instruction. One can easily see, likewise, that it is no small matter to follow through the research of finding the one method

*The Principles of Scientific Management, by Frederick W. Taylor, M.E., ScD., Harper Bros., New York, 1911, 144 pp. Primer of Scientific Management, by Frank B. Gilbreth, D. Van Nostrand Co., New York, 1912, 108 pp.

of doing a job which is better than all others. It took Mr. F. W. Taylor, a man with a master mind, twenty-six years to amass the data from which were evolved his standards for cutting metal, and even then he needed outside help to work out the conclusions. It is also easy to see that the transition from the ordinary type of management, where everyone is allowed considerable freedom of action, to one where each step is carefully planned in advance, must be gradual to avoid unnecessary friction and unpleasant feeling between workman and employer. How then can such a system be installed successfully in a few brief months? How can a few outsiders come into a plant and in a short time, a matter of months, rather than years, become experts in that particular line of business, and regulate its processes from raw materials to finished product? Yet that is one of the dangers which at present besets scientific management. Why is it, in this day and generation, that no truth can be found without being seized upon by some man with a good business head and commercialized to its own great detriment?

Scientific management, as has been aptly said, is evolution, not revolution. It cannot be installed by settling down on a plant with a great blare of trumpets, and with a few brief time studies, some graphs of machine operations, and men's efficiencies, and a chart of bonuses. It cannot be realized by destroying the old which has been gaining in strength for centuries and, in a few months, setting up a wonderful new management, perfect in every detail. No such glorious creation will arise from the ashes of the old. We no longer believe in phoenixes. Sometimes we wish we might. It is easier.

Scientific management is evolution, not revolution. It does not seek to tear down, but rather to use the old as a foundation and build toward the new. Nature had evolved over part of the earth a wonderful flora and fauna before the glacial period. Then came the ice age and the old was blotted out, leaving Nature to evolve a new flora and fauna in its place. It may very well be that Nature has done better this last time, but it must be at least admitted that she was set back a considerable period of

time. It is just so in a change of type of management, a revolutionary change means a setback.

How then can such radical changes be brought about? The most natural way is to start with "the management," which must first be imbued with the spirit of the game. Then a department of properly equipped men under "the management" may be organized who will follow the work through. Here too, caution must be observed lest this department fall into the error of certain other systematizers and attempt to make the change all at one time. The change must be gradual and thorough, "precept must be upon precept, line upon line, here a little and there a little." Great patience and tact must be observed. Coercion should give way to "moral suasion" if it is possible. The feeling should be of mutual helpfulness rather than antagonism, but in all probability the man does not live who could make the whole change with such consummate skill and tact that no feelings would be injured. Thus, step by step progress can be made toward that ideal goal of perfect manufacture, which can never be attained and only approached through the path of earnest and diligent effort.

LIMNOLOGY AT SQUAM LAKE

CARL MARSH, '12

During the summer of 1913, the School of Engineering of this University offered for the first time a course entitled Limnology, under the guidance of Professor G. C. Whipple, assisted by Dr. Bunker and Mr. Schattschneider. Although lasting but two weeks at the Harvard Engineering Camp at Squam Lake, the results obtained in this first venture promise interesting times for those taking the course in the future, and data of value to several branches of engineering and science.

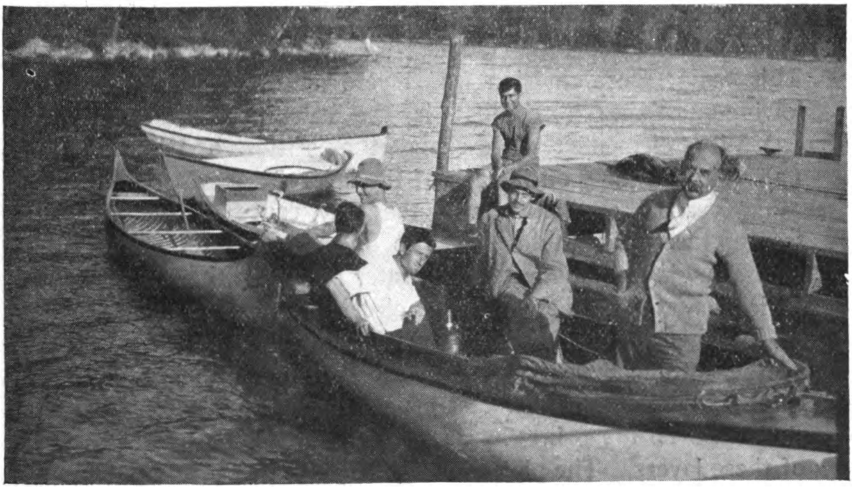
The observations made during these two weeks are stepping-stones towards a determination of the relations between atmospheric conditions, physical conditions of land and water, and chemical and microscopical conditions of the water in a lake or reservoir. In order to make a complete study of the above relations, it would be necessary to determine the topography of the country surrounding the lake, the hydrography of the lake, and make continuous observations over a long period of time of all atmospheric conditions, temperatures, currents at various parts of the lake and at all depths, chemical properties, and microscopic and bacteriological analyses. Obviously all this cannot be accomplished in two weeks by a party of ten, so that the observations made so far can hardly be relied upon to establish definitely any of the above relations, although they may serve to indicate interesting possibilities.

HYDROGRAPHY.

As no complete hydrographical survey of Squam Lake was available, the first step was to begin a series of soundings. For the first season the work consisted of establishing a line of soundings between the Engineering Camp and High Haith, a line down the middle of Harvard Cove, enough lines to give the hydrog-

raphy of Bean Cove, and lines forming a triangle from the Camp to High Haith to the southern end of Yard Islands. From these soundings, two deep holes were located and buoyed, one about 55 feet deep between Camp and High Haith, called the Barrel, and one about 70 feet deep in the center of the Camp-High Haith-Yard Island triangle.

To locate these soundings, two methods were used: the first by establishing signals at prominent points on the shore and taking sextant sights from the sounding boat on three of the signals (three pointing) with every second sounding; the second, by rowing from one point on the shore to another on the opposite shore and counting the number of strokes at each sounding. This second method gave usable results in a light wind, but the flat-bottomed boats that were used did like to drift and swing with a heavy wind in spite of the efforts of the helmsman.



The Fleet

TEMPERATURES.

As soon as the deep holes were located, daily observations of the temperature of the air and surface water, together with notes on the atmospheric conditions were taken near the shore, and the

temperature of the water at various depths was determined at the barrel. All of the water temperatures were observed by the use of the thermophone, an electrical device based on the principles of the different resistivities of metals and the Wheatstone bridge, giving results to the nearest tenth of a degree (Fahrenheit). The observations at the deep holes were taken from boats, but the surface readings were made by suspending the thermophone coil from a small float at anchor and running the cable to a tent on shore. The air temperatures were observed in the shade near the shore.

The temperature curves for the water at various depths give a very good indication of what is going on underneath the surface of the lake. The observations, taken the latter part of August and the first part of September, show that for a distance of from 25 to 35 feet vertically, the temperature is nearly the same, but that within the next few feet the temperature change is very rapid. Below this change, which will be called the transition zone, the temperature again varies but slightly. This temperature division into layers naturally raises the following questions: (1) What is the cause of this division? (2) What elements tend to change the positions of these layers? (3) What is going on in each of the layers?

If vertical circulation was the only cause of the varying temperatures, we would expect to find warm water at the surface changing gradually to cold water below, so the observations indicate that it is the horizontal circulation, due to currents set up by winds or other natural forces and guided by the contours of the bottom, that is the chief cause of the division. If it is the horizontal circulation that causes the division into layers, it must also be the principle element in determining the positions of these layers. The plot showing temperatures at the Barrel on succeeding days (Fig. 1) indicate that this supposition and its natural conclusion are probably correct. The first case of August 20, when the readings were taken after a period of quiet water, shows a high position of the transition zone, while the observations of August 25 and 28, each taken after a high wind, show the transition zone in a much lower position. Unfortunately

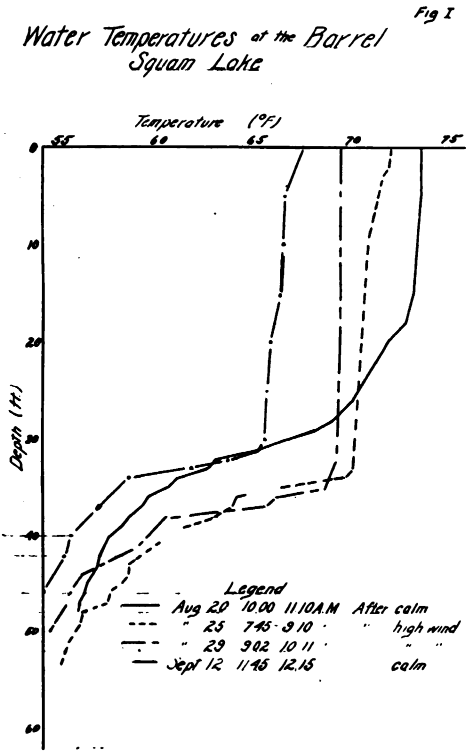


Fig. 1

the wind was in the same direction on both occasions, so that it is impossible to tell the part the bottom contours play in the distribution. The last observation on September 12 was taken after thirty-six hours of calm, and although the top layer was much cooler than on the previous dates, the transition zone was higher than at the time of the high winds. When the surface layer is cooled off to the temperature of the bottom layer, vertical circulation would be expected to cause uniform temperature throughout the entire depth until the whole body of water reaches the temperature of maximum density for water, without regard to the horizontal circulation. Although the observations

at Squam Lake were not continued late enough to show this overturn, weekly thermophone readings in a 50 foot hole at Fresh Pond this fall and many observations elsewhere give evidence of this phenomenon.

The temperatures of the surface water and air are also interesting as showing the relation between atmospheric conditions and the temperatures of air and water. The plot of surface

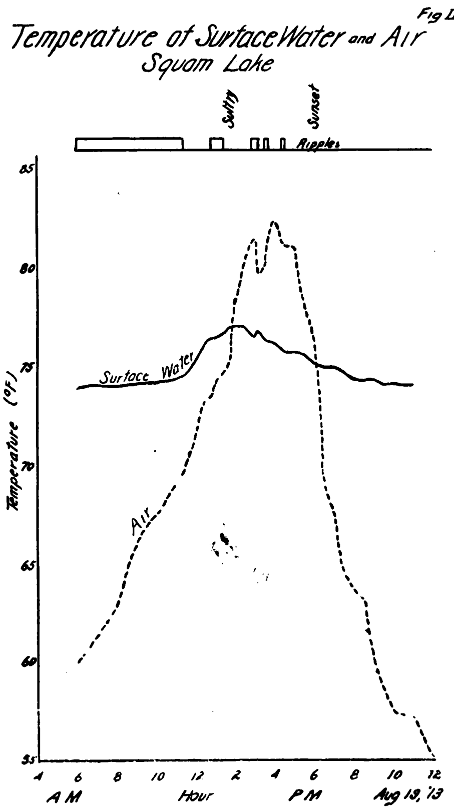


Fig. 2

water and air temperature for a typical day (Fig. 2) shows how the surface water varies over quite a wide range on a hot, calm day, and how easily it is affected by a slight breeze or

clouds, as at 3.30 P.M. It is also interesting to note that the water temperature rises while the air is still considerably colder, and falls while the air temperature is still above that of the water. Even on days when the air temperature failed to rise to that of the surface water, the same rise and fall in the water temperature was observed. These observations were continued from the time the course started on August 18 until September 26, and during this period the average daily temperature fell off about 10 degrees. The change was not uniform, although the fluctuations in the daily average water temperatures were much less marked than the average air temperature changes. These hourly and daily variations in the surface water apparently affect the whole upper strata, for continuous readings at the Barrel during the hourly change on August 22 showed the whole upper layer warming up as the surface water temperature near the shore increased, and the daily changes in the top strata shown in Fig. 2 correspond with the surface variations noted at the shore. Nevertheless, these changes in the temperature of the top layer seem to have no effect on the position of the transition zone or the temperature of the bottom layer.

CURRENTS.

As a further aid towards determining what is going on in each of the layers, there are the observations of currents and the chemical and microscopical analyses to be considered. At the same time that temperature readings were being made, observations of currents at various depths were attempted by the use of floats. The floats used consisted of four wings of galvanized iron, each about 18 inches square, fastened to wooden blocks. From these blocks a small wooden rod extended to the surface, on which was attached a metal flag, so marked as to designate the depth of the float. The difficulty with these floats lay in the adjustment, for when the float once had been adjusted to float at the desired depth the block would absorb enough water to cause the float to sink, and several observations were interrupted by the necessity of quickly forming a rescuing party. Nevertheless, some interesting results were obtained from these floats.

Fig. III

Direction Floats Moved from Barrel

Aug 21 Depth	Wind - South Direction
0	North
5	"
10	"
15	South
20	East
35	North east & south

Aug 26 Depth	Wind - North west Direction
6	South
7	South south west
8	" " "
9	" " "
10	" " "
11	West
11½	"
12	North west
13	North
15	North east
20	North

Aug 29 Depth	Wind - west Direction
5	East
7	"
8	"
10	"
12	"
15	"
17	"
18	South east
18½	" "
19	" "
20	South

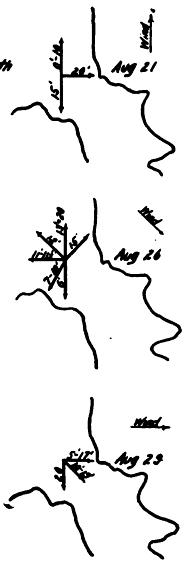


Fig. 3

In every observation (Fig. 3) it was found that the surface water travelled with the wind, but there was a current directly opposed or at right angles to the wind at some depth above the transition zone. One observation was made below the transition zone, but this showed only the slightest trace of a current in an uncertain direction.

In all of the observations it was found that, of the floats going with the wind, those nearest the surface travelled the fastest. To find out whether these floats gave good values for the velocities of the currents, a surface float was started simultaneously with some sawdust. In this experiment the sawdust moved much

more rapidly than the float, but here again the particles near the surface travelled faster than those below.

Although these observations are hardly complete enough to base conclusions upon, they indicate the possibility of a complete circulation in the upper layer with a possible slight induced circulation in the lower layer. To determine just how these currents act, it will be necessary to have a complete plot of the hydrography of the portion of the lake where the observations are made, and some means of determining the velocities as well as the directions of the currents.

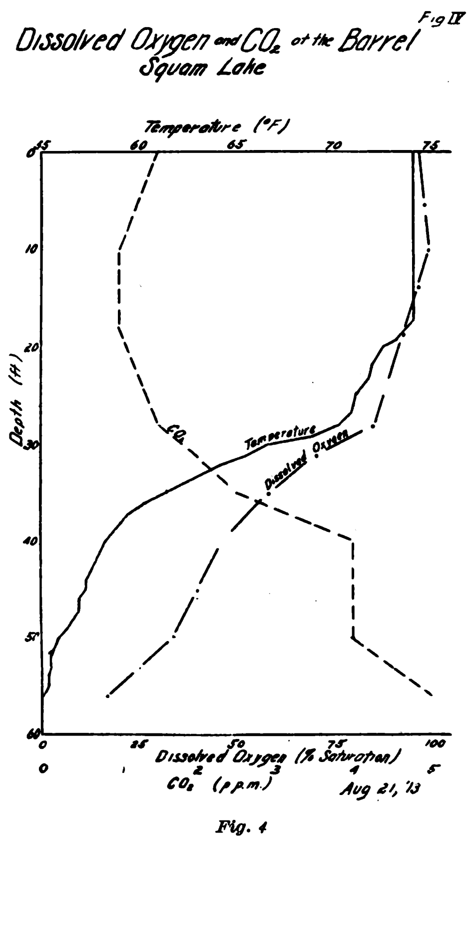


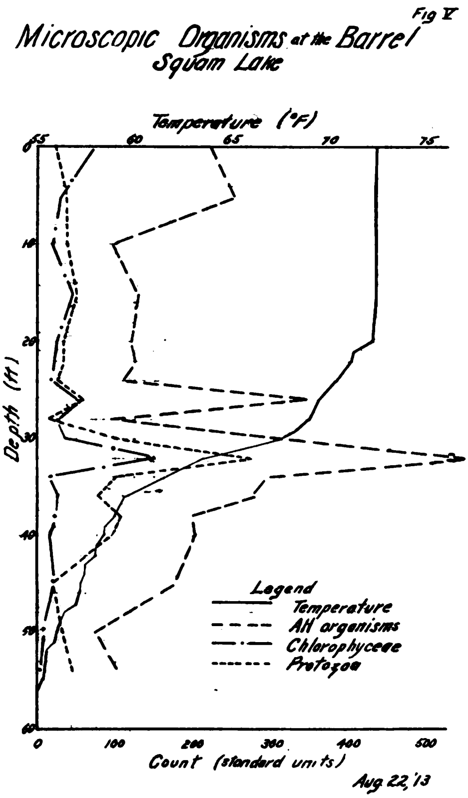
Fig. 4

Dissolved Oxygen and Carbon Dioxide.

Together with the current and temperature observations, a set of analyses was made to determine the amount of dissolved oxygen and carbonic acid in the water at various depths. A plot of the values obtained on August 21, together with the temperature curve for that date (Fig. 4) is a typical example of what the relation between these properties was found to be. In this case the carbonic acid increased and the dissolved oxygen decreased practically at the same rate as the temperature, showing the same division into three layers. This phenomenon helps to substantiate the possibility of circulation only in the upper layer and stagnation in the lower layer, separated by the transition zone of slight circulation and rapidly changing qualities. Just how much of the change in the above chemical qualities is due to the presence or the absence of circulation and contact with the air and how much is due to the microscopic organisms is hard to tell without many observations under all sorts of conditions.

Microscopic Organisms.

A count of the microscopic organisms at various depths indicates quite clearly the importance of the transition zone. The plot showing these organisms on August 22, together with the temperature curve for that date (Fig. 5) shows a marked increase in the number of organisms at the point where the temperature change is greatest. This increase was due principally to the growth of chlorophyceae and protoza at this point, as the cyanophyceae were more numerous near the surface and the diatoms were scattered throughout the entire depth. The most noticeable increase of any one kind was in the case of dinobryon, although there was also a marked increase of aphanizomanon and mallomonos. All of these organisms contain chlorophyll and need cool water, light, and carbon dioxide to make them thrive. For this reason they are likely to be prolific in the transition zone where they get the best combination of these elements. Moreover, if there is a current just over them returning from the shore, the food supply also would be greatest at this point. Naturally we would not expect always to find the greatest growth



of organisms in the transition zone, as many organisms thrive under conditions that could be fulfilled better at a different depth, but these observations indicate that it would do no harm to avoid the transition zone with an intake for a water supply whenever possible.

These observations are just the beginning of the work in this course. With future classes to check or disprove the points brought out here and to establish new relations between the elements of limnology, there is no doubt but that much interesting and valuable material will ultimately be collected.

EXPERIENCES WITH THE UNITED STATES COAST AND GEODETIC SURVEY*

P. S. DONNELL, 1 G. S.

The discussion this evening will be divided into two parts:—a general account of the history and activities of the Service and then a few illustrations of the work as seen at close range.

The beginning of the work was authorized by Congress in 1807, but not much was accomplished until 1816 on account of the War of 1812, and the necessity of obtaining abroad both the instruments and the men for the work. From this insignificant beginning with foreign material the Survey has grown to be the greatest institution of its kind in the world, and the instruments produced under its supervision are used in many of the great surveys, as, for example, that of India. Then too, all the important ports of the world obtained their predicted tides for three years in advance, from the Washington Office.

Authorized only for the survey of the Atlantic Coast, the scope of the work has since increased enormously, not only in magnitude, but into various other activities than those originally contemplated. Beside the three main divisions of the work—Triangulation, Topography and Hydrography—there is the Gravity Work, Magnetic Work, Precise Levelling and Boundary Work, of which latter a great deal has been done in the last few years.

Gravity Work includes not only the determination of the magnitude of the force of gravity, but also its direction, which has a very important bearing on Latitude and Longitude determinations. In the Magnetic Division the direction and strength of the earth's magnetic field are determined at various points, not only on the coast and at sea but throughout the continent. Next to the general surveys the Precise Leveling is the work of greatest importance. The precise level developed by the Department has been brought to a remarkable degree of efficiency and

* Summary of a lecture delivered before the Harvard Engineering Society, November 7, 1913.

accuracy, and with this instrument lines of levels have been run across the country both from north to south and from east to west, making it possible for nearly every place of importance to know its elevation above sea-level to within a few millimeters.

The work of the General Surveys is always, where possible, taken up in the following sequence: Triangulation, Topography and Hydrography. The difficulties involved in the Triangulation vary enormously with conditions, the work being very simple where there are bare, sharp mountains and very difficult where the mountains are flat-topped and covered with the dense and tall tropical foliage. The latter is the normal condition encountered by those working in the Philippines. After the mountain tops which have been decided upon as giving the required strength of figure, are located and reached, it is necessary to determine which will prove the cheaper, with the same accuracy, clearing the lines of sight or building a tower. As a rule a tower is built to a reasonable height, depending on the class of material available, and a small amount of clearing is done. In the ordinary jungle the height of the towers ranges from seventy to one hundred and thirty feet. The main scheme stations being established, secondary stations are located wherever convenient for topographic control.

The Topography of the Survey is always done with the plane-table and usually on a scale of one to twenty thousand. The prime aim of the Topography is to locate exactly the coast line and prominent topographical features, as seen from the sea, and, by means of sketched contours, to give, as accurately as possible, an idea of the country. As the Triangulation is, I think, the most interesting work of the Service, so the Topography is undoubtedly the most exciting, especially along the open stretches of the Pacific where there is always a surf.

The Hydrography is done in two parts: the small-boat work, usually done by a launch, in the shallower water, by the use of the leadline and hand sounding machine; and the ship's work in the deeper water, done usually with the steam sounding machine making either vertical casts or using sounding tubes.

THE PROPOSED NEW WATER SUPPLY FOR OKLAHOMA CITY, OKLAHOMA*

THEODORE R. KENDALL, '12

The need of a new water supply for Oklahoma City has been apparent for a number of years, droughts and large fires in summer having at times greatly overtaxed the existing supply, which is taken from the North Canadian River near the city, filtered, and then forced into high pressure mains, there being no high pressure storage.

In July, 1911, a commission was appointed to consider a new source of water supply, and make a detailed report of the project with costs.

The various steps in such an investigation are, (1) future population, (2) future increase in per capita consumption, (3) sources of supply. This last topic was necessarily divided into two parts by the nature of the available sources in Oklahoma, (1) remote sources, (2) nearby sources, the latter being further subdivided into (a) shallow wells underlying the bed of the North Canadian River, (b) deep wells in the "Red Beds," which are sedimentary strata of Perinian or Triassic origin, and form the bed rock of that region, (c) the North Canadian River.

Even brief consideration eliminates the remote sources as too expensive. Shallow wells near the city could scarcely provide sufficient water in the future. The deep wells are subject to the same objection. Thus the North Canadian River supply was carefully studied.

The report of the Commission recommends the diversion of water from the North Canadian River at El Reno, about 28 miles above Oklahoma City at times when the waters are comparatively free from turbidity. A dam with flood gates and weir diverts the water to silt settling basins, which are operated alternately.

*Summary of a lecture delivered before the Harvard Engineering Society, October 24, 1913.

Leading towards Oklahoma City and paralleling the North Canadian River is an open ditch canal 27 miles long, 27 feet wide at the top, 8 feet at the bottom, and 4 feet deep, having a capacity of 125 second feet. A short distance north of Oklahoma City the water enters a covered concrete aqueduct 1500 feet long, then flows under Putnam City, a suburb of Oklahoma City, in a 3000 foot tunnel. From the tunnel it flows to the storage reservoir through a covered aqueduct.

The storage reservoir is 2½ miles from Oklahoma City and is to be built progressively as more storage is needed by slowly increasing the height of the dams and dykes. The ultimate storage capacity will be 3 billion gallons, which is sufficient to carry the city through the worst drought which rainfall and runoff records show would be possible within the period for which this project is designed.

A bypass canal carries excess water around the reservoir and supplies water for the hydro-electric plant, which up to 1920 it is estimated will do seven-tenths of the pumping.

The project calls for frequent and extensive enlargement of the present filtration plant and clear water wells. Twenty-two filter units with a capacity of 1,000,000 gallons per day will be added by 1930, with accompanying enlargements in the coagulation basins.

The total cost of the project will be $1,552,800, and construction is expected to begin at an early date.

COMPARATIVE APPLICATION OF GAS-ELECTRICS, STORAGE BATTERIES AND TRACKLESS TROLLEYS*

G. HALL ROOSEVELT, '13

The class of transportation under consideration is for "feeders" or "feelers," exclusively; it cannot compete in heavy trunk-line work where the steam locomotive is now rather hard pressed by the high-tension systems.

The gas-electric finds its best field in the traffic of high speed, long headway interurbans, or as an auxiliary for the steam line on 150 mile daily runs where the steam train of two coaches and full crew is maintained at a loss. This latter type of line is found in country which has died out, and similarly in virgin soil where the future promises a lively traffic.

It is this same hopeful enterprise that has called the "trackless trolley" into existence, but as an auxiliary of the ordinary tram in the European suburbs. It is essentially an omnibus propelled by electric power drawn from two parallel overhead wires through the medium of poles unusually long to allow lateral movement to either curb. The evident advantage is the elimination of the initial investment in tracking, minimizing the equipment necessary in a development where the headway is expected to be 30 minutes or so, and permitting of power transmission through the trolley wire exclusively. In England the suburban "trackless" is "run in" a considerable distance on the tracks of the tram line, of which it forms the extension that the transfer at the junction may be eliminated. This form of locomotion is evidently more comfortable than omnibus riding owing to the smoother motion permitted by the electric drive and the absence of vibration. The 'bus has, however, the economic advantage of not being limited to one route so that it may follow the traffic, but the high operating expenses limit its sphere of action to the denser portions of the big cities.

---

* Summary of a lecture delivered before the Harvard Engineering Society, December 5. 1913.

A practical and economical storage 'bus would be a tremendous success, as it would combine the comforts of electrical locomotion with the flexibility of detached vehicles. But the storage battery is still a slightly uncertain and rather expensive article of commerce and has found a field in this country chiefly in dense traffic, low speed, city work where one of its chief recommendations is the possibility of purchasing cheap power. Every precaution has to be taken to reduce train resistance as the starting current is the objectionable part of the system. Hence cars are brought down to about 400 pounds per passenger, which permits of making the battery small enough to be removed for charging and inspection. The possibility of charging in the hollows of the load curve recommends this system to the large station men. Large, high speed, storage battery units are used on 1000 miles of the Prussian State railways, but in this country they have never been practical owing to the rougher handling and differences in traffic conditions.

HARVARD ENGINEERING JOURNAL

A QUARTERLY

DEVOTED TO THE INTERESTS OF ENGINEERING IN HARVARD UNIVERSITY

THE OFFICIAL ORGAN OF THE ASSOCIATION OF HARVARD ENGINEERS

Published four times during the college year by the Board of Editors of the Harvard Engineering Journal in November, January, April and June.

Subscription Rates

Per year, in advance $1.00
Single copies 35

Advertising rates will be furnished on application to the Business Manager. Address all communications to the heads of the respective departments:—

HARVARD ENGINEERING JOURNAL,
Room 218, Pierce Hall,
Cambridge, Mass.

Entered at the Post Office, Boston, Mass., as second-class mail matter, June 5, 1902.

New policies and progressive legislation are factors in the development of governments and societies. Remarkable development in the Harvard Engineering Society is evidenced by the adoption of an important new policy concerning the recording of lectures delivered at its meetings. Heretofore abstracts of the

lectures have appeared in the records of the Society alone, and have come to light only when "read and accepted" at the following meeting. The few departures from this practice have been the publication in full in the JOURNAL of such exceptional lectures as "The Mississippi River Dam at Keokuk, Iowa," by Minton M. Warren, and "The Graphical Solution of Engineering Problems," by Seldon S. Yates.

At the Society's first meeting of the year members of the Executive Committee discussed with several members of the JOURNAL Board the feasibility of publishing in the JOURNAL an abstract, written by the author, of each lecture delivered before the Society. It was decided to test the value of the plan by its adoption for the coming year. Thus valuable lectures will no longer be buried in the records of the Society, but will be presented in such form that all members of the School and Graduates may, at a glance, see the general nature of each address, and profit from its store of useful information.

The JOURNAL takes great pleasure in commending this new policy, and presents in another part of this issue abstracts of the first three lectures.

During the Panama-Pacific Exposition in San Francisco there will be an International Engineering Congress, September 20 to 25, 1915, with the purpose of bringing together a large and representative body of engineers to interchange views on the various phases of professional work. Colonel George W. Goethals will act as Honorary President and is expected to preside over the general sessions. The work of the Congress will be divided into sections, each covering a definite field, as follows: waterways and irrigation, railways, materials, mining and metallurgy, naval architecture and marine engineering, mechanical, electrical, municipal, and military engineering. Eminent engineers will read papers which are to be discussed carefully and thoroughly. The papers and a summary of the discussions will be published in a set of 10 volumes, each of 500 pages, six inches by nine inches. It is intended that each paper shall treat of its assigned topic in

a broad and comprehensive way, with especial reference to recent development. A full bibliography of the original papers and sources will add greatly to the reference value of the work.

Colonel Goethals has promised his aid in securing a definite and authoritative series of papers discussing the engineering problems of the Panama Canal. This will be made a special feature of timely interest. The section on Electrical Engineering is limited to papers dealing with the interdependence of Electrical and other fields of engineering work by agreement with the Congress of Electrical Engineers whose meeting immediately precedes.

Excursions are planned for the inspection of engineering works especially typical of practice on the Pacific Coast.

The membership fee of five dollars includes a volume reporting the general proceedings and containing indexes and digests of the other volumes, any single volume of the Transactions which the member may select, and full participation in all the privileges of the Congress. Fuller information may be got from the chairman of the Publicity committee, Mr. W. A. Cattell, Foxcroft Building, San Francisco.

ASSOCIATION OF HARVARD ENGINEERS

At its November meeting the Council fixed the date of the next annual dinner as the night before Commencement, June 17th, at 7 P.M.

After a discussion of the suggestion from one of the members that two or more names for each officer to be elected appear on the ballot for election of officers, it was voted to retain the old form of one name only.

The nominating committee for officers for next year is as follows:

J. R. WORCESTER, *Chairman*
HOWARD ELLIOTT
FREDERICK A. DELANO.

ADDENDA TO ASSOCIATION YEAR BOOK.

Garland, Kimball Rogers, A.B. 1911; M.C.E. 1913, Civil Engineer, 5 Woodside Ave., Winchester, Mass.

Harris, William Bernard, A.B., 1913, Villa Nova, Pa.

Morse, Arthur Morse, S.B. 1901, Sup't and Mech. Eng'r, Baldwin Piano Mfg. Co., Cincinnati, O.

NEW ADDRESSES.

W. E. Clark, 69 Newbury St., Boston, Mass.
L. N. Clinton, 6 Channing St., Cambridge, Mass.
W. S. Higgins, Univ. Vt., Burlington, Vt.
Gorton James, 145 High St., Naugatuck, Conn.
P. M. Patterson, 109 Lyman St., Springfield, Mass.
R. B. Pendergast, 33 Summit Ave., Brookline, Mass.
S. K. Roy, 13 Walter Hastings Hall, Cambridge, Mass.

ADDRESSES WANTED.

The Secretary of the Association would be very glad if the following addresses could be supplied:

M. E. Brookman, 1907-09
P. D. Hawkins, 1907
C. A. Sargeant, 1906.
Lyon Smith, 1905.

HARVARD ENGINEERING SOCIETY OF NEW YORK

The schedule of meetings of the Society for 1913-14 is as follows:

Sept. 5, 1913.	Smoker at Harvard Club.
Oct. 25, 1913.	Excursion to Ellis Island Immigrant Station. Evening meeting at the Harvard Club with lecture by a representative of the New York Department of Health.
Dec. 1913.	Annual dinner, date and place to be announced later.
Jan. 10, 1914	Evening meeting at the Harvard Club. Papers by members of the Society.

Feb. 14, 1914. Excursion to Jacob Ruppert Brewery. Evening meeting at the Harvard Club.

Mar. 25, 1914. Smoker at the Harvard Club.

May 1914. Excursion to Steamship "Imperator." Evening meeting at the Harvard Club. Date to be announced later.

June 6 or 13, 1914. Annual meeting and field day, date and place to be announced later.

The first regular meeting of the Society was held in the small meeting room of the Harvard Club on Friday, September 5, at 8.15 P.M. President Finlay announced the following appointments for the year 1913-1914:

Sub-Committee on Admission—Mr. George S. Rice, Chairman, Mr. Charles Gilman, Mr. C. M. Holland.

Committee on Meetings—Mr. Roger C. Barnard, Chairman, Mr. J. R. Healy, Mr. R. R. Rumery.

Employment Committee—Mr. J. P. H. Perry, Chairman, Messrs. Thos. Crimmins, R. R. Rumery, R. C. Barnard, J. P. Hogan, H. M. Hale, Charles Gilman.

Recruiting Committee—Mr. Dean G. Edwards, Chairman, Messrs. Francis Mason, Harrison Weymouth, John H. Hall, W. C. Brinton, J. F. Gowen.

The representatives of the above committees present appointed the following members to serve on the Committee on Publication: Mr. R. R. Rumery, Chairman, Messrs. George S. Rice, R. C. Barnard, J. F. Gowen.

The Secretary announced the election of Wallace E. Belcher, '04, and J. C. R. Palmer, '04.

The second meeting of the year was held on October 25. In the afternoon an inspection trip was made to the Ellis Island Immigrant Station in New York Harbor, after which members of the Society took dinner at the Harvard Club. In the evening an illustrated lecture was given by Mr. Edward D. Very, Sanitary Engineer of the New York City Street Cleaning Department, upon the work of this department. About 40 men were present.

On Tuesday evening, October 28, members of the Society were guests of the Princeton Engineering Society at the Princeton Club. Mr. F. O. Blackwell, President of the Princeton Society, gave an illustrated lecture on Mexico.

The annual dinner of the Society was held at the Harvard Club, New York City, on Saturday, December 20, 1913, at 7.30 P.M. All Harvard men interested in engineering were cordially invited to attend the dinner whether a member of the Society or not, and the undergraduates who attended were cordially welcomed at the dinner. The price was $3.50 per plate.

ROGER C. BARNARD, *Chairman Committee on meetings.*

HARVARD ENGINEERING SOCIETY

On October 24 the Society was addressed by Mr. T. R. Kendall on "The Proposed New Water Supply for Oklahoma City." On November 7 Mr. P. S. Donnell spoke on "Experiences with and Work Done by the United States Coast and Geodetic Survey in the Philippine Islands." On December 5 Mr. G. H. Roosevelt spoke on "Comparative Applications of Gas-electrics, Storage Batteries, and Trackless Trolleys." Abstracts of these lectures are given in an earlier part of this issue.

ERNEST L. ROBINSON, *Secretary.*

HARVARD WIRELESS CLUB

The Harvard Wireless Club has had several meetings this fall and is started on a very interesting year's work. Several more speakers well known in the field have been secured for early dates, and a course in wireless telegraphy, adapted to the needs of the non-technical man, will probably be started in the near future. The club station has proven very efficient in operation, especially on the receiving end, messages having been received by members from many vessels at varying distances on the ocean, while press news from Wellfleet, Mass., serves as receiving practice for the less skilled. All men who are in the

least interested are urged to be present at the next meeting, the date of which will be announced in the Crimson, in the Club-room and Station at 70 College House, where they are sure to find a discussion well worth their trouble.

E. T. DRAKE, JR., '16, *Manager.*

GRADUATE NOTES

CHARLES H. MANNING, U.S.N., '62, has resigned, after thirty years as Mechanical Engineer of the Amoskeag Manufacturing Company of Manchester, N. H., and opened an office at 885 Elm St., Manchester, with his son, Charles B. Manning, as Consulting Engineers.

JOHN D. PENNOCK, '83, who has been for a long time chief chemist of the Solvay Process Company, Syracuse, N. Y., has been made general manager of the company.

JOHN COIT ADAMS, '87, died in Butte, Mont., on October 17. Mr. Adams, who had been connected with Montana mining in various capacities since leaving college in 1885, was superintendent of the mines of the Boston and Montana branch of the Anaconda Copper Mining Co.

CHARLES J. TILDEN, '96, formerly at the University of Michigan, is professor of civil engineering at Johns Hopkins University.

C. MINOT WELD, '97, mining engineer, has opened an office at 66 Broadway, New York City.

GEORGE E. CLARK, '01, is engaged in manufacturing at Windsor Locks, Conn.

GEORGE E. HOLMES, '01, is engaged in the design of Printing Presses and special Paper Handling Machinery with the Kidder Press Company, Dover, N. H. His address is 30 Lincoln St., Dover, N. H.

ERNEST I. DOE, '02, is with Stone and Webster, 147 Milk St., Boston.

William E. Taylor, Jr., '03, is engaged in the manufacture of metal and wooden wheels for agricultural implements, at La Porte, Indiana.

A daughter, Allison Williams, was born to H. M. Boylston, '03, and Mrs. Boylston on November 18. Mr. and Mrs. Boylston reside at 55 Claremont Avenue, Arlington Heights, Mass.

Walter M. Stone, '04, has been engaged in engineering work in San Francisco, for the past two years. He has just returned to Boston and is at present with the Boston and Maine Railroad. His address is Summer St., Waltham, Mass.

Ralph Valentine Bunting, '05, has been missing since June 27. He was last seen at Portland, Maine, on June 27, and disappeared the same day. During the past winter he had been troubled with headaches, and it is thought that he may have become mentally unbalanced. Any information in regard to him should be sent at once to his father, William Bunting, 9 Tremont Place, Boston, Mass.

A son, Edward Robinson Lyon Smith, was born to Lyon Smith, '05, and Mrs. Smith on October 24 at Blair, Nevada.

Philip M. Patterson, '05, is an electrical engineer in the Springfield office of Fairbanks, Morse and Company of New York. His address is 109 Lyman St., Springfield, Mass.

John R. Nichols, '06, is an engineer with the firm of Monks and Johnson, Boston.

George W. Waller, '07, who has been for the past three years in the cost department of the John A. Roeblings' Sons Company, Trenton, N. J., is now assistant to the mill superintendent.

Harry F. Gould, '07, who has been for several years an assistant forester with the Massachusetts State Forestry Department, has resigned to take up the active management of the Franklin Forestry Company, with nurseries at Colrain, Mass., and offices at 89 State St., Boston.

Edson W. Cook, '08, is an insurance engineer and is at present inspecting and reporting on large industrial plants through

the Middle Atlantic States. His address is 647 South 57th St., Philadelphia, Pa.

Edric B. Smith, '08, is junior assistant manager of the Rockefeller Institute for Medical Research, New York City.

Gorton James, '08, has changed his address from Room 5054 Grand Central Terminal, New York City, to 145 High Street, Naugatuck, Conn., and has taken a position there as Assistant to the Factory Manager of the Rubber Regenerating Company.

Walter L. Remick, '09, is with the experimental department of the Alaska Gastineau Mining Company, Mill Camp, Juneau, Alaska.

John J. Fitzgerald, '10, is in the engineering department of the Hugh Nawn Contracting Company, Boston.

Warren Ordway, '10, is with the Lamson Store Service Company, Lowell, Mass. His permanent address remains 111 Gibbs St., Newton Centre, Mass.

Arthur T. Derry, '10, is metallurgist with the Youngstown Sheet and Tube Company. His address is 77 Falls Avenue, Youngstown, Ohio.

J. Jarvis Preble, '10, is resident engineer at Sparrow's Point, Maryland, for the Spray Engineering Company, of 201 Devonshire St., Boston. His permanent home address remains 90 Church St., Waltham, Mass.

William F. Ryan, '11, M.M.E. '13, is in the engineering department of the Interborough Rapid Transit Company, New York City.

Everett A. Brotchie, '11, is a salesman with the Barrett Manufacturing Company, coal tar products, Boston. His permanent address remains Stony Brook, Mass.

Edward W. Ellis, '11, who is with Lockwood, Greene and Company, architects and engineers for industrial plants, has been transferred to Canada. His address is 907 McGill Building, Montreal.

Lincoln C. Torrey, '12, is in the engineering corps of the Pennsylvania Railroad, Lines West of Pittsburg; his headquarters are at 1013 Penn Avenue, Pittsburg.

G. Morrison, '12, is with Stone and Webster. He is at present engaged in the investigation of the Chicago Elevated Railroad.

James Biggar, '13, is chemist with the Illinois Steel Company, Gary, Ind. His address in Gary is 775 Jefferson Street.

Hamilton V. Bail, '13, is with the United States Aluminum Company of New Kensington, Pa. His present address is Parnassus, Pa.

Clyde B. Long, '13, is engaged as mechanical engineer in the remodelling of the power plant, etc., of the State Infirmary at Tewksbury, Mass. His permanent address is 105 Norton St., Dorchester, Mass.

Otto R. Frasch, '13, is with the Western Electric Company, Hawthorne Station, Chicago, Illinois.

Millard B. Gulick, '13, is with Cram, Goodhue, and Ferguson, architects, 15 Beacon St., Boston.

J. Rea Baker, '13, is with Stone and Webster, 147 Milk Street, Boston, Mass.

George M. Graham, '13, is a chemist with the E. I. DuPont de Nemours Powder Company, Chester, Pa. His address in Chester is 915 Edgmont Avenue.

Martin T. Fisher, '13, is with Wilkinson, Giusta and Mackay, patent lawyers, Ouray Building, Washington, D. C. His address in Washington is 1802 Wyoming Avenue.

Bruce W. Davis, M.E.E. '13, is an electrical engineer with the Lincoln Electric Company, Cleveland, Ohio.

Charles S. Brisk, Gr. Sc. '13, is a sanitary engineer with the New York Public Service Commission, New York City.

Gustav A. Reinhardt, Met. E. '13, is with the Youngstown Sheet and Tube Company, Youngstown, Ohio.

George H. Hazlehurst, M.C.E. '13, is a sanitary engineer in the relief department of the Atlantic Coast Line Railroad Company, Wilmington, North Carolina.

Samuel Barron, Jr., '14, is with Rice and Hutchins, shoe manufacturers, South Braintree, Mass.

Ernest L. Fuller, '14, who is chief draftsman for Arthur F. Gray, mill architect and engineer, 53 State St., Boston, was married on June 4 to Miss Blanche M. Miller at Haverhill, Mass.

PERSONAL NOTES

Professor G. C. Whipple has been appointed Chairman of the Committee on Statistics of Water Filtration of the New England Water Works Association.

Mr. Allen A. Prior, M.E.E. '13, has been appointed Assistant in Electrical Engineering for the second half year.

Recent Publications by Harvard Men and by the Staff

"The Berlin Meeting of the International Electrotechnical Commission; Advance Report to the United States National Committee." Professor A. E. Kennelly. *Proc. Am. Inst. El. Engineers.* November, 1913.

"Sewage Disposal,—What Can a City do to Solve the Problem?" Professor G. C. Whipple. *Proc. of Conference of Mayors of State of New York.* 1912.

"Thermal Testing Plant at the Pennsylvania State College." J. A. Moyer, S.B. 1899, A.M. 1904, Professor in charge of Pennsylvania Experimental Station, Pennsylvania State College. Paper presented before the International Congress of Refrigeration, Chicago, September 17, 1913. *Abstracts in Eng. News,* October 9, 1913; *Power,* November 11, 1913.

"City Planning." James S. Pray, Chairman, School of Landscape Architecture, and Theodora Kimball, Librarian, School of Landscape Architecture. *Harvard University Press,* 1913.

"Kinetic Effect of Crowds," C. J. Tilden, '96, Professor of Civil Engineering, Johns Hopkins University. *Trans. Am. Soc. Civil Engineers.* Vol. LXXVI, p. 2107.

NOTES

On Saturday, December 13, the first-year men of the Engineering School did battle with the representatives of the School of Architecture on Soldiers Field. The Engineering team was composed of the more aggressive spirits of Eng'g. 2L, whose official yell was properly patterned after that of Cornell. A large and enthusiastic crowd cheered the combatants on to touchdowns, but both teams lacked the final punch. The first score was earned by a brilliant end run by E. A. Graustein. The second score resulted from a still more startling feat. Captain Gardner placed the ball on the ground and, while the opponents were consulting a rule book to determine the ball dead, holding the ball with his left hand, kicked with his right foot a beautiful goal from touchdown. Score, Engineers 7, Architects 0. The Architects put up a well designed defense, but their structure failed under the catapultian attacks of the Chief Engineer. In the second half no further score was made, proving the need of the final punch—for the victors to celebrate.

INDEX TO ADVERTISERS

Merged in: Technology monthly

APRIL, 1914

THE OFFICIAL ORGAN OF THE ASSOCIATION OF HARVARD ENGINEERS

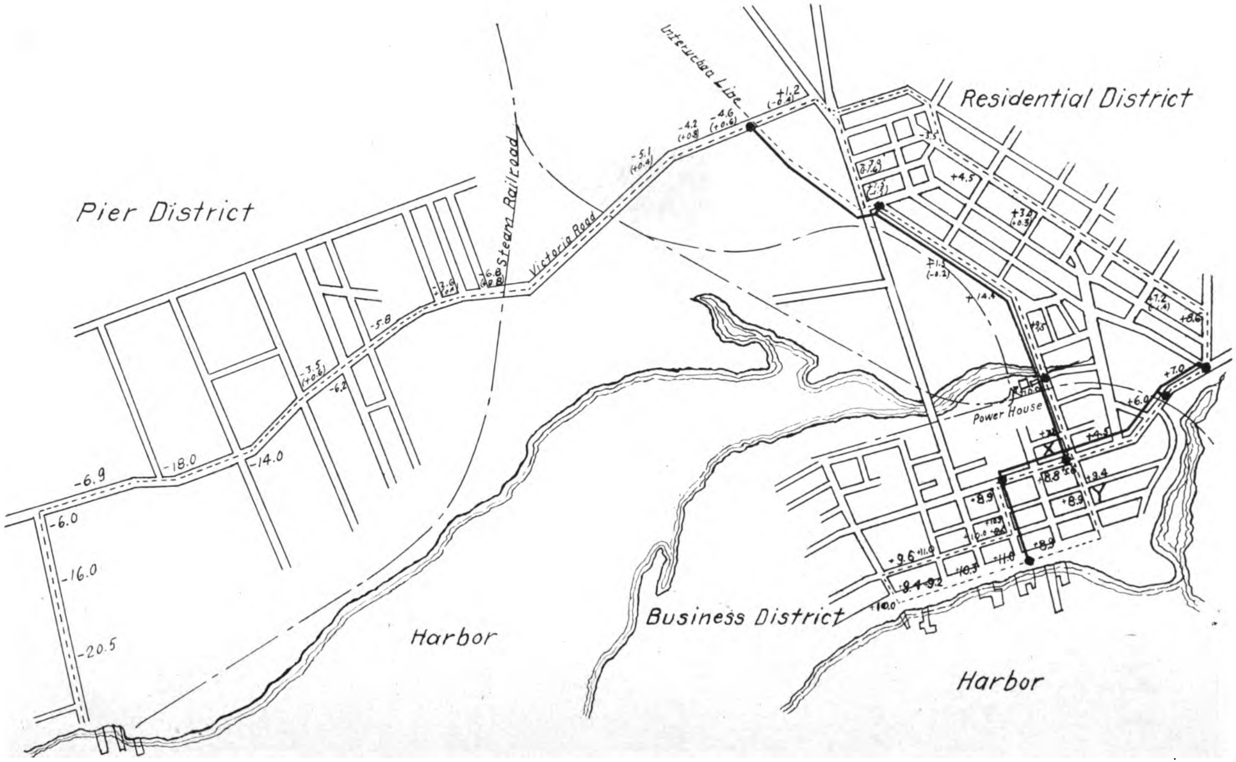
HARVARD ENGINEERING JOURNAL

A QUARTERLY
DEVOTED TO THE INTERESTS OF ENGINEERING IN HARVARD UNIVERSITY

VOL. XIII. TABLE OF CONTENTS No. 3

Price 35 cents

MAP SHOWING ELECTROLYSIS READINGS



(An Electrolysis Survey in a Small City)

HARVARD
ENGINEERING JOURNAL

A QUARTERLY

Devoted to the interests of Engineering
in Harvard University

THE OFFICIAL ORGAN OF THE ASSOCIATION
OF HARVARD ENGINEERS

VOL. XIII APRIL, 1914 NO. 1

AN ELECTROLYSIS SURVEY IN A SMALL CITY

F. A. HUBBARD, 3G.S.

In the summer of 1913 I devoted considerable time to the study of electrolysis on the street railway system in a city of about twenty thousand inhabitants. Since the number of such surveys which have been published is very limited, it has seemed to me that some account of it might be of interest to readers of the JOURNAL. There are, moreover, certain special features in the case which are worthy of attention. I shall therefore, after mentioning in a very brief way the underlying principles of stray-current electrolysis, describe the situation in the city in question, give an outline of the work which I have performed, and show what has been done, and what might have been done, to improve conditions.

This question of electrolysis due to stray currents from street railways is one which has cost the profession a great deal of anxiety and money in the last twenty years. In a number of cities, municipal regulations have compelled the local companies to take very elaborate measures to minimize its effects. I say "minimize" advisedly, since that is practically all that has been accomplished. The currents which cause the electrolysis are enabled to stray, due to the almost universal practice of using the rails of an electric railway system as the return circuit. In extreme cases this practice has had to be given up,—Cincinnati,

for instance, has been compelled to adopt a double trolley system, —but normally the immense saving from such use of the rails outweighs its disadvantages. The rail is nowadays always connected to the negative terminal of the generator, the trolley and trolley feeders to the positive. This puts the negative terminal at something like zero potential, since the rails are not insulated from the ground. In the early days the scheme was sometimes tried of making the earth itself the return circuit, but this had to be given up, on account of the high resistance of such a return.

Consider the current taken by a car somewhere out on the line. It attempts to return by the rail, which presumably offers a metallic path back to the power house. But it strikes the end of a rail. The contact resistance of the rail and fish plate amount almost to an open circuit. If there is in the neighborhood a metallic path of any reasonable conductivity, such as a gas or water main, or the sheath of a telephone cable, the current will leave the rail and start home on the new conductor. This process does not injure the pipe or cable, since it is the positive electrode which is affected. When the current reaches the power house, however, it must leave the pipe, and ordinarily return to the rail, since it is the latter which is tied to the negative side of the generator. It is at this point that the pipe or cable, being positive, will be pitted, or sometimes eaten completely away.

The first step toward preventing this performance is to reduce the resistance at rail joints by bonding, that is, connecting a piece of copper cable around the joint to make a bridge for the current. The resistance of a well-bonded joint should be equivalent to not over three feet of rail, and is often very much lower; it is customary to add 15% to 20% for bond resistance. Bonding, if thoroughly done and well kept up, will do a great deal toward getting rid of electrolysis; but after the lapse of four or five years it is a question how many of the bonds are still in place. But even if the bonding is good, some stray currents will continue to exist. This follows from the fact that there will be a difference of potential from point to point in the rail, due to the passage of the main return current; and as

the resistance of the ground path is fairly low, a certain proportion of the current will follow this path. Given a rail so bonded as to be in effect continuous, the potential difference per unit length of the rail will be a measure of the tendency to stray currents; and for this reason, in some cities municipal regulations define the allowable drop. In general it should not be over one volt per thousand feet, and the lower the better.

Efforts at electrolysis prevention fall into two general classes: (1) work on the pipe or cable, increasing its resistance, bonding it to the rail, etc., and (2) reducing the drop in the rail by returning a part of the current to the power house through directly connected feeders. Insulating joints are frequently put into the pipe line to prevent it from carrying any large amount of current. The Boston Elevated and some other companies have found this to work very well. It is somewhat expensive, especially on old pipe lines, as the joints must be put in freely or they are of no value; it may also lead to corrosion of the pipe around the joint. A still more common method is to bond the pipe or cable directly to the rail in the regions where the latter is at negative potential. This is known as "draining," and is especially used on telephone cables, which furnish a nearly continuous metallic path. The object is to get the current out of the cable into the rail without letting it pass through the ground, which would pit the cable. The system is objectionable because it rather encourages stray currents than tries to prevent them, and may lead to electrolysis at other points, and because the connecting wires sometimes have to carry very heavy currents. The same is true of another system occasionally used, of running feeders from the negative bus out to points on the pipe or cable. Both systems are strongly condemned by the Bureau of Standards.

A more rational method is to reduce the voltage drop in the rail, by returning some of the current by special feeders. Obviously, if all points on the rail were at the same potential as the negative bus, there could be no stray currents, whatever that potential might be with reference to the ground. Similarly there would be none if the bus were insulated from the ground, and all

the rail at a uniform potential, whatever the latter be with reference to either ground or bus. Each of the negative feeder systems tries to approach one of these two conditions. If the negative bus is grounded, almost the entire track will be at a positive potential, becoming very large at a distance from the power house. The resulting ground currents will be very large. If the bus is insulated, it and the rails for some distance from the power house will be negative, and only the more remote portions can send currents into the ground, since what leaves the rail must now get back to the rail, and cannot enter the power house through the ground wire. This leakage will be still further reduced by the lower positive potential of the rail at distant points. It has been shown (G. I. Rhodes, A. I. E. E. vol. xxvi.) that, assuming uniform resistance and load distribution, the earth current is reduced by 80% by simply insulating the negative bus, without the use of any return copper.

The disposition of the negative copper is designed to approach one of the conditions mentioned in the last paragraph. The usual system,—that adopted in Chicago, for instance,—is to run either uniform or tapering feeders out over the entire line, tied to the track at frequent intervals. This, of course, requires a great deal of copper, even if it is so tapered as to secure a uniform voltage gradient in the feeder. It simply parallels the return path of the rails, and leaves in them a voltage drop similar to, although less than, the original. A better and more economical system is to establish one or more points on the rails at reduced potential by insulated feeders running out and tied to these points only. In the article before quoted, Mr. Rhodes shows that on the assumptions already stated, a single feeder of moderate size is of much greater value than the same weight of copper distributed on the system. The addition of another feeder improves matters still more, if the two are properly spaced, and so adjusted, by resistances or negative boosters, as to put the two connected points at the same potential. This subject is admirably covered in the article already cited, in one by Rosa and M'Cullom of the Bureau of Standards in the

Electric Railway Journal for January 3, 1914, and by certain regular publications of the Bureau of Standards.

Now to turn to the investigations in which I had a part. The layout of the part of the city served by the railway is shown in the accompanying map. It may be roughly divided, as indicated, into the business district; the residential district, served by the "Avenue Line," with half-hourly service; and the Pier district, chiefly composed of the residences of the poorer class of employees of the steel works. The "Pier Line" has three cars an hour throughout the day, the rush hour traffic being handled by using larger cars, and by running two cars together at the regular times. The cars of both lines run around the loop in the business district, as does also the hourly car from the interurban line indicated on the map. The power house is located as shown, close to an arm of the harbor.

Trouble with electrolysis began soon after the road was started, some fifteen years ago. Both the city water mains and the telephone cables have suffered (there is no gas supply in the city). At the point marked X, the telephone company was forced twice within five years to renew a cable which ran parallel to the tracks. Trouble with the water pipes is frequently developing. Last summer a leak was reported at the point marked Y on the map, and I happened to be on hand when the investigation was made. A ½ inch lead service pipe ran from the main to a house on the other side of the street, passing under the tracks at a depth of about four feet. At the two points directly under the rails, the service was completely eaten away, while at other points it was perfectly sound.

The standard method of testing for electrolysis is by measuring the voltage between the rail and the water mains at the various hydrants along the car line. It is necessary to take readings at each point for quite a length of time, the longer the better; to get really reliable figures, they should cover all possible positions of the cars. In this series, readings were generally taken for about five minutes at each point. This would give a fairly good line on what was going on, especially if the maximum reading occurred repeatedly, as it did in most cases. It must of course

be noted in which direction the voltage reads, and the meter should be provided with a reversing switch to follow reversals, which are very likely to occur at certain points on the line. When the hydrant is negative with respect to the rail, the current is leaving the rail for the water pipe; when it is positive, the current is leaving the pipe for the rail. This last indicates danger from electrolysis.

On the map the figures give the maximum observed voltage of hydrant with respect to rail. The "danger zone," therefore, is in the region covered by the positive readings. It corresponds roughly with the business district, including a little of the residential. The greater part of the latter may be classified as almost neutral. The readings shown are the maximum obtained in either direction, but in most cases in this region both positive and negative readings were observed in the course of the five-minute test. The "Pier" district, together with most of the length of Victoria Road down to the Pier, is covered by negative readings. In this section the current is leaving the rail for the pipe.

It will be noticed that the power house stands close to an arm of the harbor, on land which is low and presumably saturated with salt water. An attempt was made, some years ago, to establish the negative bus at zero potential by means of a heavy ground cable coming into intimate contact with the water. At the same time a piece of 4—0 wire was run into the water at the extreme end of the Pier line. Within two weeks' time the latter was completely eaten off; and fearing that the ground connection of the negative bus was offering altogether too much encouragement to the stray currents, the company cut the ground cable, and it has never been used since. In view of the facts pointed out above, this was probably a wise change. Last summer there was a practically steady voltage of 17 across the break. That is, instead of being at nearly ground potential, it was at 17 volts. About this same voltage existed from the bus to the water and steam piping in the station, and also to the frame of the reserve railway generator, which was presumably grounded. The frame of the generator most used, however, was

for some reason connected to the positive brush of that machine, so that it was kept at 500 to 600 volts above the ground and all neighboring iron work. It was thought for a time that this might have had some bearing on the electrolysis situation; but the hydrant-rail voltages at a number of different points proved to be practically the same for either generator, so this stupid arrangement apparently had no effect beyond the danger in the station.

A number of years ago, when the city authorities began to agitate seriously against the electrolysis, a similar survey was made, resulting in a very similar distribution of voltage to that obtained by me last summer. The data obtained were submitted to a firm of engineers, for them to recommend measures of remedy. On their advice, a system of return feeders was installed, as indicated by the heavy lines on the map, connected to the track at several points, shown by heavy black dots. The purpose of this is the same as in the cities above referred to: to supply a return path of sufficiently low resistance to prevent the current from going to the water pipes. It is one of the simplest and most effective methods in use, when properly carried out. This was a number of years ago, but the trouble still continues; and the map made up from my readings shows little improvement over that made from the original data. The feeders installed were, as marked on the map, one of 300,000 circular mills to the business district, covering roughly the whole of the "danger zone," tied in at five points, besides the direct connection to the track in front of the power house; and one 4—0 wire running out about a mile toward the Pier district, tied in at the junction of this line with the interurban, and at one intermediate point. It represented a very considerable investment for a small company, and apparently showed little result. Is there a reason for this?

To study the value of the feeders, additional tests were made. The readings along Victoria Road were repeated with the return feeder to that region disconnected. The readings ran slightly smaller as to maximum values of the voltage, rail positive; but at every hydrant, sometime or other in the test, the voltage

would reverse, showing hydrant positive for a moment. On the face of things, this feeder made matters worse when it was in, and it certainly did not cause any great improvement. All that this set of readings proves conclusively, however, is that the bonding is very poor all along the line. For some reason, the most important reading for this analysis, that at the hydrant close to the end of the feeder when the feeder was connected, was not obtained; in fact a number of readings above that point, were measured only with the feeder disconnected. We can only guess, therefore, that this should have showed a marked swing to the rail-negative condition. This would indicate that the elimination of the rail-negative readings down through the Pier district, and the slight increase of rail-positive readings noted, was due to a concentration of the flow of current to the rail in the immediate vicinity of the end of the feeder. But in any case, we must conclude that this feeder is doing little or nothing to improve the situation, chiefly because the bonding in its vicinity is so poor as to isolate it.

Another experiment consisted in cutting out the feeder to the business district entirely, except in front of the power house, and taking readings through that district. The developments here were curious. The readings were much larger, hydrant positive, at the first five or six stations from the power house; but beyond that, as far as could be judged from consideration of the position of the cars, there was almost no effect. The readings were carried out beyond the furthest connection of the feeder in the residence section, still without marked difference. The one startling result obtained was at the two hydrants in the business district farthest removed from the power station, which showed not only a marked reduction of hydrant-high voltage when the feeder was disconnected, but actually swung to reversed readings. The indications from this apparently discordant set of readings are that the presence of this elaborate system of feeders to the "danger zone" simply produces a distribution of the area in which the current is flowing from pipe to rail, lessening the concentration in the immediate vicinity of the power house, but spreading it farther over the business section. It is able to effect this on

account of the very good bonding which prevails in this district, thanks to a substantial pavement. The latter obviously tends to hold the bonds in place. A survey made of this region with a bond tester showed almost no joints of measurable resistance.

While this cut in the feeder to the business district was still open, tests were made to find out the amount of current it had been carrying, by placing pieces of fuse wire across the gap. A 20 ampere fuse lasted for several hours, going out toward the end of the afternoon. A 60 ampere wire lasted over night, and possibly two or three days, apparently being burnt out by some sudden rush of current. In general, then, this feeder was returning from 20 to 50 amperes maximum, and less than 20 for a good part of the day: this for a size of wire normally allowed to carry 400 amperes, and having a resistance of less than 0.2 ohm per mile! The current in the other feeder was not measured.

What, then, has been accomplished by this system of large, expensive return feeders to the business district? It is the district where the bonding is of the best, where the normal return circuit by way of the rails is most satisfactory. The feeder system simply parallels this already low resistance path. So far it is justifiable to some extent. But what current is it collecting? Obviously that which is coming from the water pipes to the rail, and which is making the electrolysis trouble. In other words, it is making it possible for the current which is going to the water pipes at the other end of town, to return to the rail over a larger section of the city than would otherwise be the case. It also returns to the power house, to be sure, the current used by the cars in the business district, where the three lines come together, and where the number of cars is greatest. Well and good; but this current gets back to the power house satisfactorily without it, as far as electrolysis is concerned, showing little or no tendency to leak to the water pipes when the feeder system is disconnected. From the point of view of maintaining the voltage in the business district by providing a low-resistance return path for the relatively heavy currents used there, it is of service; but it does nothing,—it can do nothing,—to prevent the

current from passing to the water pipes, for that is taking place at the opposite end of town.

The difficulty with the system as installed must be apparent at once from the above discussion. It is *upside down.* The function of return feeders in a railway system, as far as regards electrolysis, is to provide a return path of very low resistance so that the current will not be compelled to take to the water pipes to get back to the power house, in other words, to reduce the potential drop along the rails. But it is obvious that the only place where the current can be prevented from going to the pipes is where it shows a tendency to do so; and that to supply an easy path for its return to the power-house after it leaves the pipe for the rail, is simply locking the door after the horse has been stolen.

One of the first things necessary to improve the situation is careful testing of all bonds, especially along the Pier line, and renewal of those which are defective. I have reason to believe that there are many such, although my own testing stopped at the junction of the Pier and Avenue lines. There were certainly plenty in the region I covered. I know from my hydrant readings that the extreme end of the Pier line, beyond the last turn, was almost entirely isolated from the rest of the line, for when an inward-bound car rounded that corner, the voltage on the last two hydrants would at once drop from 15 or 20 volts to zero, and remain there until another car came around the corner. The same condition undoubtedly prevailed pretty much all along the line. The bonding is expensive to install, and expensive to keep up; but it is absolutely necessary for satisfactory conditions. If this were done thoroughly, it is very likely that the present feeder running toward the Pier would improve matters sufficiently down there,—on the principle before noted of putting different points of the line at the same potential,—if it were not for the other feeder system. . The latter establishes the business district at a voltage not more than 5 or 6 volts higher than the negative bus. The copper necessary to do the same for a point even half way to the Pier would be hopelessly large, without the assistance either of a negative booster in this feeder, or a resistance in the uptown

one. The system is badly overbalanced. In view of this situation, and of the poor condition in which the bonds would probably be in a short time, it might be best merely to extend the existing feeder to the Pier, tying it in frequently. The design of a complete scientific layout to reduce the troubles to a minimum would be interesting, but too long to be taken up here.

ECONOMICAL OPERATION OF FORGING HAMMERS

H. L. LINCOLN, '06

In many machine shops there is much work that must be done with forging hammers, which are usually driven by steam supplied from a boiler plant. Modern methods, however, make it advisable, in many cases, to replace steam with air as an actuating medium. In either case there is much that the hammer man can do to cut down the cost of operating the hammer through his control of the valve and consequently of the action of the hammer. As the valve controls both the admission and the exhaust ports, the operator can vary the length and speed of stroke, and back pressure, thus having absolute command of the energy to be used for any piece of work.

In a shop doing a large amount of forging, steam used in the forge shop will frequently exceed the power requirements of the factory. This was so in a plant which has come under the writer's observation. The manufactured product was crank-shafts and connecting rods for automobiles. The power plant consisted of one 250 and two 150 H.P. boilers. In the regular twelve hour working day 15 tons of a low grade Illinois coal were burned. A 275 H.P. Corliss engine was carrying a load of about 150 H.P. and required about 5000 pounds of steam per hour, leaving not less than 5000 pounds to be supplied to the steam hammers. Under these conditions the same care that prompts adjustment of valves and development of engines to a high degree of efficiency, demands an analysis of the losses in forging hammer operation. When steam is the motive power, the skillful use of the valve results in a direct saving of coal, and hence dollars. When, however, a more radical change is made in the power supply, a far greater saving may result, not so much from the actual operation of the hammers, as from general economic conditions throughout the plant. At present the best engineering practice points toward the concentration of generating power into centrally located plants, often of immense size and delivering electrical energy

throughout a wide territory. Such a system is primarily based on the suppression of isolated steam power plants, thus saving in investment, labor, supplies and maintenance, to say nothing of the general relief of the management from power plant worries and uncertainties. Where the factory is operating steam hammers, some medium must be used to replace the steam and this medium is commonly compressed air. While the substitution has in itself certain inherent advantages, they do not materially affect the result and so will not be discussed in this paper.

On the more vital question of operating economy we need more assurance, and if we consider a typical plant using two or three hammers, of perhaps 1500 pounds weight each, we will find that there is a very decided saving resulting from their adaptation to compressed air. For example: The cost of power in a certain plant is made up of the following items:

Coal	$12,200
Water, Oil and General Supplies	2,000
Labor	4,000
	$18,200

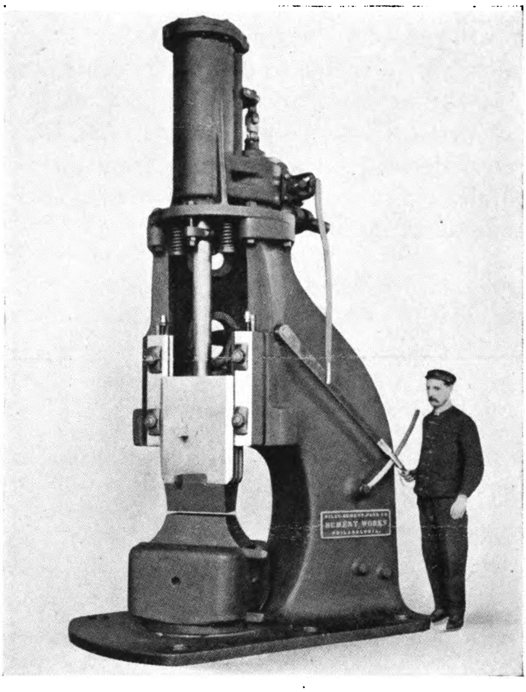
This same plant can be operated with service purchased from an electric supply company, in which case the cost of power is as follows:

Electricity	$10,000
Coal for heating	3,000
Supplies and maintenance	500
Labor	1,600
	$15,100

Obviously it would be absurd to allow the imagined demands of the forge shop to stand in the way of this change and thus prevent a saving of $3,100.00 a year, or, expressed in another way, interest on over $50,000.00 which could be used in developing the business of the concern. As it happens, not only can this economy be effected, but the accuracy, reliability and safety of

the hammers will be increased by the substitution of compressed air for steam, so that an investigation of its operating characteristics is well worth while.

Such an investigation was made by the writer in connection with some recommendations regarding the supply of service to several manufacturing plants. Fortunately there was accessible



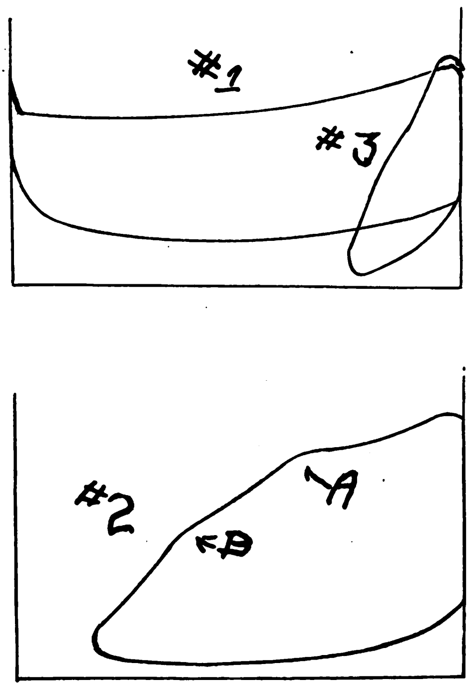
1500-pound Steam Hammer

a factory using five drop hammers originally designed for steam but operated by compressed air supplied by a 900 cubic foot motor-driven air compressor. The weight of the ram and attached parts of three of these hammers was 3000 pounds, and that of the other two, 1500 pounds. They had been operated by air for some time before the factory's power plant was replaced by purchased power, because of the greater reliability and accuracy which

could be obtained by compressed air. In these hammers air is only supplied below the piston to raise the hammer which is allowed to drop by its own weight. In many types of hammers steam is admitted above the piston to increase the speed and force of the blow. Part of the time, on some classes of work, this is not necessary and by a suitably designed valve could be avoided. At present the result is accomplished by working both the throttle and operating lever, but this requires an especially skillful operator and in many shops is neglected, nor is it likely to attract the foreman's attention as it affects the economy and not the quality of the hammer's operation. However, a consideration of this feature complicates the subject and as it adds to the losses rather than counteracts them, will be disregarded in this discussion. The hammer shown in the accompanying illustration is of this type, but those tested differed from it only in the action of the valve. They were controlled by an operating lever, as shown, which is raised from the neutral to admit steam (or air) and depressed to open the exhaust. The operator controls the length of stroke by the amount of air he admits to the cylinder and the force of the blow by the extent to which he opens the exhaust valve allowing the ram to fall. In fact, he can let it fall half way and stop it, and in ordinary operation may frequently check the force of the blow by closing the exhaust before the end of the stroke, as shown in the following indicator cards.

These cards were taken from typical isolated strokes, and while the first one rarely occurs in actual work, the second and third were repeated many times during the course of the test. No. 1 shows a full, slow stroke in which the piston was raised and held at the top of the cylinder as indicated by the full line pressure at the end of the stroke. The operator then partly opened the exhaust valve, allowing the hammer to fall slowly against back pressure, which was increased at the end of the stroke, resulting in a light blow although a full cylinder of air had been used. Card No. 2 shows a heavy blow in which less air is used. A full head of air was admitted to the cylinder, the admission valve closed partly at A, partly at B, the exhaust then opened wide, allowing the hammer to fall free. This gives the heaviest type

of blow which, with this hammer, could only be exceeded by lifting the piston to the extreme end of the stroke. Of course, it would be greater if steam had been admitted to the top of the piston or, as in a compound hammer, the steam exhausted from below the piston and admitted above it, utilizing the expansive



Indicator Cards from 1500-pound Steam Hammer

No. 1. Long stroke, light blow
No. 2. Normal heavy blow
No. 3. Short, light blow

power of the steam. This principle has been used in some lines of hammer and appears to increase the economy to a considerable extent.

The third card shows a correctly applied light blow, the hammer being lifted only far enough to give a blow of the force re-

quired. This not only saves time and hence increases the output, but also reduces the load on the air compressor, and decreases the cost per unit of output. Comparing this with the first card, although the blow may be as hard, or harder, approximately one-eighth the air was used. While this, of course, is an extreme case, it shows the amount of air or steam that can be wasted in operating the hammers themselves. It disregards leakage, condensation and other losses which are sure to be heavy and which have earned for steam hammers the reputation of being "most uneconomical pieces of machinery, to be endured rather than desired."

Before discussing further the action of these hammers, we should have some idea of the different types of work done, which affect greatly the relation of economical operation of the hammer itself to the cost of power to the factory. In some conditions, as already shown, it is obvious that power should be furnished by an outside company and the hammers operated from an air compressor. Under other conditions, while it may be economical to operate them this way, it certainly does not look so from a first consideration of the situation. The efficiency of steam hammers taking steam from a boiler located close at hand is recognized as greater than that of hammers driven by compressed air supplied by a motor driven air compressor which is supplied from a plant several miles distant. The losses of 75% in the turbine, 10% in the generator, 15% in transmission line, 10% in the motor and 20% in the air compressor cannot be made up by the greater efficiency of the large boiler plant. But there is no advantage in obtaining high efficiency in one department if, in doing so, the entire facory loses, as it does when the over-all power costs could be reduced by a change in source of supply. To be sure when in comparison to the rest of the factory, the forge shop is large and uses steam uniformly throughout the day, the economical use of compressed air is doubtful. But where is the dividing line? Without trying to answer this question, which obviously will differ for each factory, it is interesting to consider some of the conditions which may guide our recommendations when face to face with such a problem.

Without question, the easiest situation to handle is where there are one or two small or medium sized hammers, used in connection with a blacksmith's shop, which are operated at irregular intervals, usually on work requiring much handling so that the actual steam or air used is relatively small and would barely increase the load on the air compressor equipment. Such a shop comes in the class that is obviously adapted to the use of compressed air.

When a shop uses the same style of hammer on regular work in connection with the output of the factory, the problem becomes more complicated and the solution less clear as the number of hammers increases. If these hammers are doing typical drop forging work, they are likely to be operated consistently throughout the working day. The work frequently will require twenty to twenty-five blows per piece, and the operator will be able to turn out perhaps ninety pieces per hour. In the course of his work, however, many of his blows will be light ones, often as many as two-thirds being of the type shown in the third card. This gives the operator a chance to show his skill and to reduce the power cost to the plant. The third type of work consists in forging from heavy stock instead of drop forging, and frequently requires a series of full strokes for perhaps a minute or more at a time. Such work might be done at the Watertown Arsenal or at the Navy Yard, when making crane hooks and similar heavy forgings.

Looking over these types of work, it is evident that we must know the duty on a hammer and the number of hammers before determining the amount of air to be required. Furthermore, there are two radically different quantities to be determined, one, the amount of air required at any one time, to determine the size of the air compressor; the other, the quantity of air that will be used each day, as upon this will depend the electricity used and hence directly the cost of the air, for there is no dodging the bill from the electrical power company.

Now while air compressors are rated by the dimensions of their cylinders, as are engines and pumps, thus 16 x 10 x 14 giving the diameter of the cylinders and the stroke, they are usually in-

stalled with a storage tank to neutralize the effect of sudden or momentary loads. Thus, an amount of air perhaps twice the capacity of the compressor may be supplied for a few seconds without causing a fall in pressure. In this way it is possible to rate the compressor in cubic feet of free air per minute instead of cubic feet per stroke, which would correspond to the horse power of an engine. Our first problem then, is to determine the maximum cubic feet of air that a shop will require.

Suppose we consider a shop manufacturing small tools such as wrenches; and assume that there are in use six 1500 pound hammers having a stroke of 30 inches and requiring 10.75 cubic feet of free air per full stroke compressed to 90 pounds; that in average work the hammers take 40 strokes per minute; and that the working day is 10 hours. If all should operate continuously at full stroke, they would require 6 x 40 x 10.75 = 2,590 cubic feet of free air per minute. As the rating of the hammer is by the weight of the ram and attached parts, it is convenient and customary to express the air requirements in terms of 100 pounds weight of hammer, which, in this case, would be 2,590 divided by 6 x 15 cwt. or 30 cubic feet of free air per cwt. Such a condition is impossible where there are many hammers in use, or under working conditions as outlined above, for each hammer will be working part of the time at light load, as before mentioned, and part of the time will be taken up in reaching for new stock as the duty cycle on each piece is only forty seconds long. Further, the dies must be changed at more or less frequent intervals so that we will come closer to actual conditions by an analysis on another basis.

Even in this shop there are likely to be occasions when special work must be done and it is advisable to assume that two of these hammers might be doing such work at the same time, and that they would take full strokes continuously for several minutes at a time. Coincidently, four of the hammers would be taking 30 half strokes per minute, and the other hammer, 20 half strokes. Thus:

$$2 \times 10.75 \times 40 = 860$$

$$3 \times \frac{10.75}{2} \times 30 = 483$$

$$1 \times \frac{10.75}{2} \times 20 = 107$$

1450 cubic feet of free air,

or 16.16 cubic feet of free air per cwt. of installed hammer capacity would be required at this time, determining the size of air compressor to supply this shop.

What will be the amount of energy used by this plant per day? As before suggested, it will not amount to 16.16 x 60 x 10, because it is impossible for a shop of this size to maintain its maximum load all day. The two hammers on special work are doing heavy work for a moment or two but would be idle a considerable part of the time. The other hammers would be delayed by lack of stock, the changing of dies, or tiring of operators. This diversity results in a specific consumption frequently not exceeding one-half that of the maximum demand as outlined above, dependent, of course, upon the number of hammers and the character of the work. In a small shop with only a few hammers, several are likely to be working at once, putting a heavy load on the compressor. Similarly, several hammers may be changing the dies at the same time, resulting in a very light load. Thus, the average air supplied per minute, as shown by dividing the output of the compressor by the minutes of operation, would be a small percent of the maximum load on the compressor. (See footnote.) On the other hand, when many hammers were in use, the average load would be more constant and the maximum would not greatly exceed it.

This condition is well illustrated in the test above referred to where the work permitted about 25 strokes per minute (1,506 per hour). The indicator cards showed an air consumption of 7.2 cubic feet per stroke, which was checked by the output of the compressor after allowing for leakage (about 10% in this case). Translating this expression from cubic feet per stroke

If this average were on the basis of 24 hours a day operation, or the total air supplied during a month divided by 720 hours times 60, then the ratio of this to the maximum load on the compressor would be the "load factor" for the month, a standard relation for industrial work as used by Electric Service Companies.

to cubic feet of free air per minute per 100 pounds of falling weight, we have $\frac{7.2 \times 25}{30} = 6$ cubic feet per minute for the 3,000 pound hammer under test. This hammer was one of five in a shop which, at the time of test, was doing work that took some time for adjustment on the anvil, so that the figure is rather low for safe use generally, but it illustrates the principle of diversity in a very satisfactory manner. This is further brought out by the fact that the 900 cubic foot compressor itself was supplying, in addition to this shop, air for other uses in the factory, and part of the time was operating at light load, although there were 10,500 pounds of hammer installed which on the basis of 16 cubic feet per cwt. would require a 1,680 cubic foot compressor.

The foregoing discussion outlines the points to be considered. It would not be complete without a suggestion as to the actual requirements of several typical shops. When, for instance, the work is heavy blacksmithing, perhaps as much as 25 cubic feet per cwt. installed capacity will be required. The hammer is likely to be used for several minutes at a time, but frequently it will do absolutely no work for long periods of time. In the next class, doing much lighter work, are many machine shops where the hammer will be used intermittently and will probably require about 16 cubic feet per cwt. It will frequently be possible, however, in plants already using compressed air for other purposes, to place this additional load on the existing compressor, the diversity between it and other loads being such as not to overload the machine. Very often when it seems to be too small, a larger storage tank is all the assistance the air compressor needs.

In forging shops where the work is steady, there should be available a supply of air on this 16 cubic foot basis, but the average requirements will be much less depending on the character of the work, number of hammers and other local conditions. When using double acting hammers, as is the practice in most shops, this average throughout the day will be between 8 and 12 cubic feet of free air per minute per 100 pounds of hammer.

From this it is possible to estimate the amount of power that the forge shop will require and thus make a complete analysis of the power cost to the factory, giving a definite comparison between the cost of purchased power and that of operating the boiler plant. If this comparison shows economy on the side of purchased power, the wide-awake concern should certainly take advantage of it in spite of the inherent inefficiency in the use of compressed air in the forging hammers.

HARMONICS IN TRANSFORMERS

F. H. BEALL, '13

It is the purpose of this paper to bring out clearly the importance of the third harmonic in the exciting current of transformers, and the benefits derived by providing a path for it to flow. In order to do this the action of this harmonic and others in the exciting current must be clearly understood.

If the exciting current for an iron core circuit with sinusoidal impressed electromotive force be analyzed, it will be found to consist chiefly of a fundamental, a third and a fifth harmonic. Now in a three-phase system the third harmonic does not appear in the line voltage nor can a third harmonic current flow in the star connection when no neutral is present, since the third harmonic currents are all in phase at the centre and do not neutralize. The fifth harmonic is not affected by the 120° connection, and will always appear, therefore it can be dropped from this discussion since the different arrangement of the transformers will not stop its circulation.

In considering the behavior of the third harmonic it is best to take separately the different combinations of transformers used in practice, and show the action of the triple frequency current and voltage in them.

Delta Primary, Delta Secondary

When the transformers are connected in delta, the third harmonic voltages in the three transformers are in phase and there will be a third harmonic current circulating around the delta. Since no triple frequency voltage can appear in the line the third harmonic must be due entirely to the effect of hysteresis in the iron core. As far as this circulating current is concerned, the primary and secondary are parallel circuits magnetically connected, and the triple frequency current distributes itself proportionately to the impedance of the two circuits. In a case tested the oscillograph was placed in the secondary circuit and the resultant

circulating current consisted principally of the fundamental. The fundamental was due to the windings of the three transformers being slightly unbalanced while the third harmonic was transferred to the primary delta on account of the resistance of the oscillograph. Before the oscillograph was put in the secondary circuit, the circulating current was 0.69 amperes, and when the extra resistance was placed in the circuit it was reduced to .225 amperes, or about ⅓. The line current and voltage showed no signs of a third harmonic, which was to be expected. Since the exciting current of a well designed transformer is only a small percent of the total current, and the third harmonic is only approximately ⅓ of this, the impedance drop due to this current is very slight, and the third harmonic will not show in the impressed voltage of the open secondary delta, as the entire exciting current flows in the primary.

Delta Primary, Star Secondary

This is similar to the delta primary delta secondary when the secondary delta is open. The entire exciting current circulates in the primary delta and the only distortion in the secondary voltage is due to the impedance drop of the triple harmonic exciting current, which is entirely negligible.

Star Secondary, Star Primary

In the double star connection everything depends on the neutral. If no neutral connection exists, no third harmonic exciting currents can flow, and the resultant induced e.m.f. has a third harmonic proportional to the suppressed triple frequency exciting current, which in the average transformer is around 33% of the fundamental. Since no third harmonic voltage can appear in the line, this distorted voltage exits entirely within the windings of the transformer. If, however, either neutral is in, the triple frequency current is free to flow. In this case the impedance drop due to the third harmonic is dependent on the external impedance as well as on the impedance of the transformers, as in the case of the delta connection, and its effect may show in

the E.M.F. wave, since sufficient third harmonic E.M.F. must be induced in the transformer to drive this current through its circuit.

Star Primary, Star Secondary, Single Phase Load

This case is exactly the same as the three phase load. Since no third harmonic voltage can appear in the line no third harmonic current will flow through the load, and the impressed E.M.F. in the transformers will contain a strong third unless the primary neutral is in place.

Star Primary, Delta Secondary

This case proves to be the most interesting of all, since the third harmonic can be controlled either by opening the delta or closing the primary neutral. First consider the system without the primary neutral in place. From the oscillograph of the voltage taken across one of the transformers when the delta was open the effect of suppressing the third harmonic exciting current can be seen. In this case the third harmonic exciting current was found to be 38.3% of the fundamental, and when it was suppressed the voltage wave was distorted by this amount.

Experimental Data

(a) Delta open.

I (exc) = .98 amps.
I (delta) = 0.
E (delta) = 220 volts.
E (impressed) = 80 volts.
E (open delta) = 207 volts.

(b) Delta closed.

I (exc) = .93 amps.
(fundamental)
I (delta) = .13 amps.
(3d harmonic).
I (delta) = .365 amps. in
primary terms.
E (delta) = 220 volts.
E (impressed) = 80 volts.
I (3d harmonic) = 38.3%.

When the delta is closed a pure third harmonic current flows if the transformers are balanced. A peculiar fact arises when resistance is placed in the delta circuit. As the resistance is increased a third harmonic voltage appears sufficient to drive this curculating current through the resistance. This voltage is the sum of the voltages in the three transformers, since the third harmonic voltages are in phase, and, as the exciting current is small, considerable resistance can be inserted before much ef-

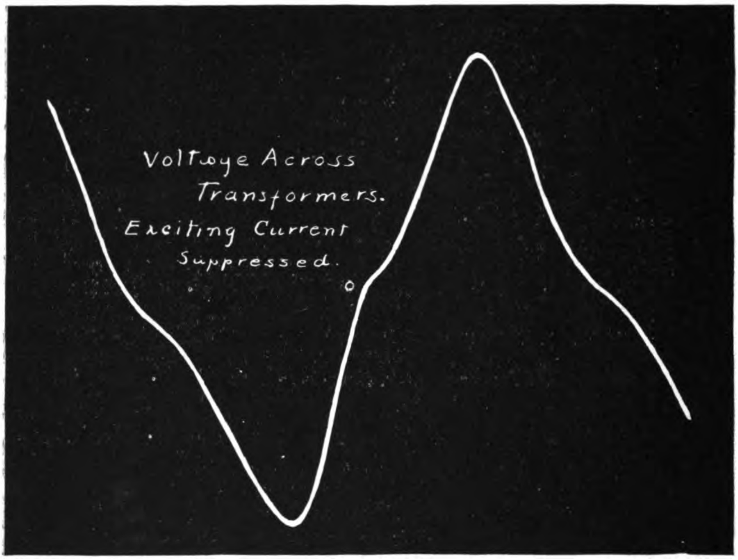


Fig. I.

fect will be noticed in the circulating current. In the case tested, when 1200 ohms were inserted in the circuit the reduction of the wave was just noticeable. The voltage necessary to drive this current of .13 amperes in the secondary was less than $1200 \times .13 = 156$ volts, since, with the increase of third harmonic voltage, there is a decrease of third harmonic current.

Now let the primary neutral be connected. When the secondary delta is open, there is a perfect third harmonic current in the neutral and a sine wave across the secondary windings. The

voltage across the open delta was reduced to 32 volts, which meant that it took $\frac{32}{3 \times 2.74} = 3.88$ volts to drive the third harmonic current of .93 amperes in the neutral, or .31 amperes per transformer, through the impedance of the transformers, connections, and dynamo windings. The ratio of transformation was 2.74. Close the delta and practically all the third harmonic current is transferred to the delta, since the impedance there is low.

Let Z_1 = impedance of one transformer
Let Z_2 = " " dynamo

Then the impedance drop per transformer

In secondary delta $= Z_1 \times I_3$
In primary $= (Z_1 + Z_2) \times I_3$

Therefore division of third harmonic current $I_3 = \frac{Z_1}{Z_1 + Z_2}$

where Z_2 is generally very large in comparison with Z_1 and we have most of the exciting current in the delta. If, however, resistance is introduced in the delta, Z_1 approaches Z_2, and more of the exciting current circulates through the primary neutral.

From these facts some interesting and important conclusions can be drawn. If the triple frequency current is allowed to flow, it is only a very small percentage of the total current, and can be neglected as far as heating is concerned in a well designed transformer. If the third harmonic current is suppressed the fundamental exciting current is also increased. This also helps to offset the gain in relation to transformer heating to be had by suppressing the third harmonic current.

Thus far it has been shown that a circulating third harmonic exciting current will not, if it is the only third harmonic current flowing, be detrimental to the operation of the transformer. Next consider the effect if suppressing this current. In this case we have a third harmonic in the voltage. This comes in such a way as to make the wave peaked, as shown in Fig. II. As the third harmonic is generally ⅓ to ½ of the fundamental, the effect of this peak is very evident. It can even be dangerous in very high

tension transformers where the factor of safety in the insulation is of necessity low. Suppose that the factor of safety is 2 and a peak of 33% is added to the fundamental. The factor of safety is then reduced to 1.5, which may prove very dangerous for long continued service.

Next consider the effect this third harmonic has on the flux wave. From Fig. II it can be seen that although there is an

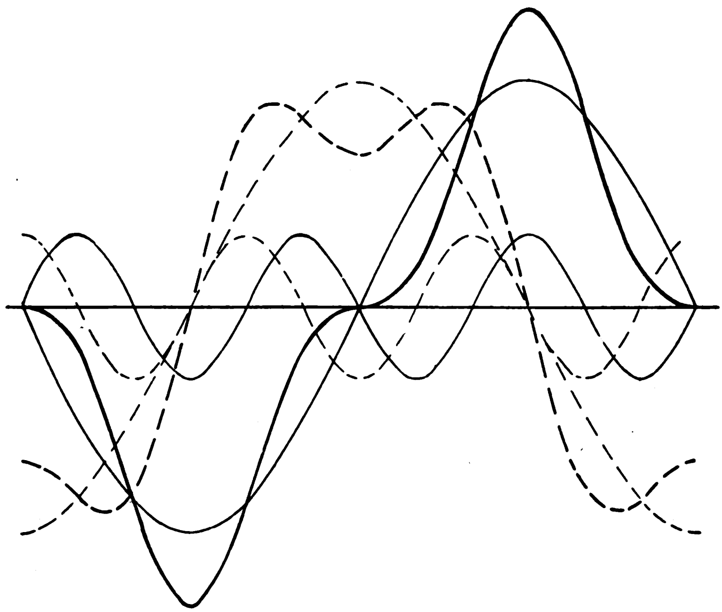


Fig. II.

Relation of Flux and Induced Voltage, Third Harmonic Exciting Current Suppressed
Heavy line = induced E. M. F.
Dotted line = flux wave

increase in the maximum voltage wave, the third harmonic in the flux wave is in phase, and there is no increase in the maximum flux in the core. This is important since transformers are generally designed to operate near the bend in the saturation curve. The only loss in this case is due to the increase in frequency of the third harmonic, and since the core losses are proportional to the square of the frequency, this may amount to

more than the copper loss of the third harmonic exciting current. There is also an increase in the fundamental of exciting current, when the triple frequency exciting current is suppressed, which gives an additional loss when this arrangement is used.

From this it is evident that no advantage is to be gained, as far as transformer heating is concerned, by suppressing the third harmonic, but in the use of high tension transformers a path should always be provided for it in order to prevent the additional strain on the insulation.

So far it has been stated that this circulating current is not of any great magnitude. This refers only to the exciting current. Care must be taken that a third harmonic voltage is not impressed on a delta. Although there is a large third in the voltage wave when the third harmonic exciting current is suppressed, this immediately disappears when the small exciting current is allowed to flow. If, however, the transformers are connected star-delta, and there is a strong third in the star voltage wave, a large circulating current can be set up in the delta if the neutral of the star bank is in. This happened on the New York Central and resulted in nearly burning out the transformers. The reason for this is easily seen. There is in each star voltage a strong third. This third is induced in the secondary delta, and since the third is in phase around the delta the result is the same as a short circuit as long as the primary neutral is in and the third harmonic current can flow in the primary. If the neutral had been left out this current could not flow since no current could flow in the primary. This same thing could happen in the connections to a rotary converter or motor. If the rotary had a strong third and was diametrically connected to transformers whose primaries were delta connected, much power would be lost in a circulating current due to this short circuited third harmonic in the delta.

Care must therefore be taken when the delta is used not to have a short circuit on an impressed third harmonic, since the loss is continuous even when the transformers are not being used. The third harmonic *exciting* current, however, is entirely negligible, and it may even be advantageous to allow it to circulate, especially in case of high voltage.

TRANSFORMER CONNECTIONS

H. L. SANBORN, '08

In considering any scheme of transformer connection, complete and detailed information is required on the whole system. The following points should be taken into consideration,—

1. Capacity of system, and each feeder.
2. High tension side for each feeder and for system.
   - (a) Whether the system must connect with others now running. If so, what are transformer and generator connections of the old system.
   - (b) Quantity of power to be transmitted and voltage.
   - (c) Method of lightning protection to be adopted.
   - (d) Type of load.
3. Low tension side for each feeder and for system.
   - (a) Method of step-down transformation, transformers, rotary converters, motor-generator sets, etc.
   - (b) Type of load: lighting, power, railway, industrial, or combinations of these.

Having decided the above to your satisfaction, the choice between "Y" and delta connections will depend upon conditions in each case. In general, the high tension side may be connected either in delta or "Y," and if the "Y" is used, the neutral point should be grounded. For the low tension side of the step-up or step-down transmission system, the delta connection is generally preferable.

In operation and construction work, however, the engineer is obliged to make many departures from standard practice. Some systems are supplied with two-phase generators in which the neutral points of each winding are connected together. In this case, simultaneous grounding or connection of any two lines from the generator, causes a short circuit on one-half of the generator winding.

The voltages and connections are indicated in the diagrams; the current in the line AA=1.41 times the current in BB or CC for balanced load. The maximum insulation stress in case of a permanent ground on this system is the same as the voltage across the lines C and B.

Considerable unbalancing of voltage at the end of a transmission line or cable is experienced with this system, due to the interaction between phases. Where the power factor is low, a

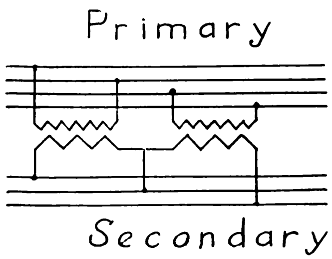


Fig. 1

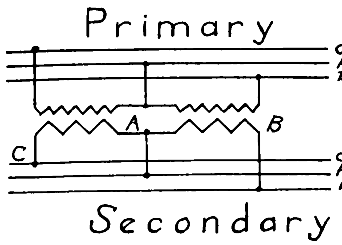


Fig. 2

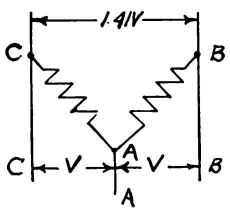


Fig. 3

still worse regulation is obtained, making satisfactory operation difficult. Very few systems now operate on this plan.

Another system is shown in Figures 4 and 5. Voltages are indicated, and the current of each coil is the same as the current in the line. If the neutral point of this system is ungrounded, the transformer insulation must be capable of standing the full voltage stress V, since a ground on any line will throw full voltage stress on parts of the transformer. Where a neutral is grounded it should be noted that a ground on the line short circuits one leg of the transformer winding. This

system is well adapted for general power transmission, but if one coil is disabled, the whole system is interrupted unless the neutral is amply grounded at both ends of the line. No stable neutral can be maintained on a bank of transformers with both primary and secondary "Y" connected when ungrounded, since it may shift to any position and cause serious unbalancing.

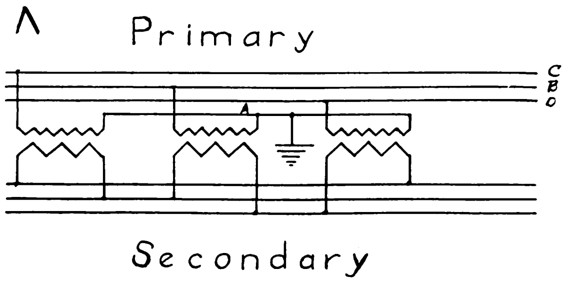


Fig. 4

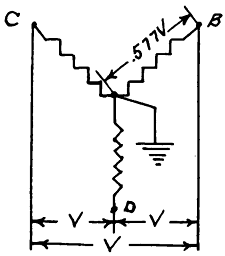


Fig. 5

Transformers with both primary and secondary connected in "Y" and with neither neutral grounded, should not be recommended.

Transformers "Y" primary and "Y"—diametrical secondary, with the exception of the three phase core type, when operating with the above connections, unless special provision is made to permit a triple frequency exciting current to flow, will have induced across their windings from neutral to line, a considerable triple frequency E.M.F. This is a maximum when the funda-

mental is a maximum, and therefore adds directly to the fundamental to increase the potential strain across the windings. The triple frequency E.M.F.'s across the three transformers being in phase with each other, do not show up in the line voltage. The triple frequency E.M.F. cannot exceed 75% of the fundamental and at the core densities commonly used has an average value of about 50%, that is, the potential strain across each transformer will be $\frac{1}{\sqrt{3}}$ or 58% of the line voltage, multiplied by 1.5.

If the neutral of the primary is grounded, the maximum voltage to ground is 58% of the line voltage, multiplied by 1.5; if the line conductor is grounded, the maximum voltage to ground is the line voltage. In any case, the maximum voltage to ground will never exceed the line voltage.

A triple frequency exciting current which will prevent the induction of the triple frequency E. M. F. can flow under any of the following conditions.

1st. If a tertiary winding is installed.

2d. If the neutral is connected to the neutral of the generator.

3d. If the neutral and line are connected to a delta bank of transformers.

4th. If the transformers are diametrically connected to a rotary converter.

Whenever no provision has been made in operating "Y"—"Y" or "Y"—diametrical to prevent the induction of the triple frequency E.M.F. under all conditions of operation, it is necessary to insulate the transformer to stand the extra strain. Such transformers should therefore, be tested to ground at twice the line voltage, and for induced potential of three times normal voltage across the windings. These tests should be applied whether the neutral is grounded or not.

Shell type, three phase transformers should have a delta connection made on the high tension windings before the triple voltage test is applied in order to prevent an unknown value of triple frequency voltage appearing in the windings in addition to that applied. This will also prevent a 300% line voltage appearing across the ends of the high tension winding.

In emergency conditions where a transformer with an 87% top cannot be obtained a teaser of the same voltage as the main transformer must be used. Two-phase to unbalanced three-phase may sometimes meet the demand. It has been satisfactorily operated for some six months during the period of change over from two-phase to three-phase.

In this connection two transformers of exactly the same capacity and voltage are used. The phases are no longer 120° apart, and it is assumed that the same connection is used at each end of the line, as this is not a true three-phase system, any at-

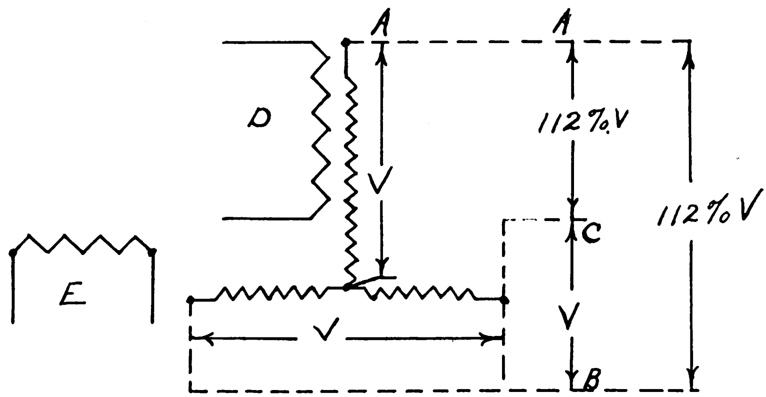


Fig 6

tempt to operate in multiple with a three-phase system, or three-phase apparatus, will cause serious unbalanced currents.

The connections and voltage relation of this system are shown in Fig. 6. With equal currents in the two-phase generator and distributing secondary, the currents in the three transmission lines will be the same as in the coils, namely A = 100 amps.; B = 112; and C = 112; with the voltage as indicated in the diagram.

It is of interest to note that an unbalancing of the two-phase distributing network (coils D and E) affects the currents in the three transmission wires as follows: Increasing the load on

phase E further increases the unbalancing, while if phase D be loaded in the vicinity of 15% in excess of phase E, the transmission line currents become practically balanced. With no neutral the maximum insulation stress under all conditions arising from a permanent ground would be 112% V.

Two-phase and three-phase may be obtained from one transformer bank. These transformer connections are seldom if ever to be recommended, but will occasionally temporarily solve some difficult situation. It is possible to provide both two-phase and three-phase secondary distribution from a primary system which is either three-phase or two-phase.

Where the primary is three-phase, two transformers may be used "T" connected both in primary and secondary. Then the three-phase current is taken from the three points of the "T" connection in the usual way and the quarter-phase by using the full secondary winding of each coil. In this case the two-phase windings are connected together and the accidental contact of any two leads will result in a short circuit.

Where the primary side is two-phase the secondary should be connected in "T" and the low tension quarter-phase and three-phase tapped off in the same manner as above. On poor power factors there will be a tendency to unbalanced voltages of the coils unless they are interlaced.

Transformers should not be connected in parallel on both primary and secondary without careful consideration of the data of the individual designs, even if they are marked for the same capacity, voltage, and periodicity, since the impedance may be so different that the load will not be divided in the proper ratio, and one or more transformers may be overloaded or heavy unbalanced currents may flow with no load on the transformers. In connecting large transformers in parallel, especially when one of the windings is of comparatively low potential, care should be taken to see that the resistance of the joints and interconnecting wires or bars does not differ sufficiently to cause the load to divide unequally.

Ten combinations of phases (neglecting voltage) are possible in parallel operation of delta and "Y" connected three-phase

transformers. In connecting up two transformer banks (A and B) for parallel operation on both the primary and secondary side, six of these will operate safely, with regard to their phase relations, viz.:—

	Low Potential Side A	Low Potential Side B	High Potential Side A	High Potential Side B
1.	Δ	Δ	Δ	Δ
2.	Y.	Y.	Y.	Y.
3.	Δ	Y.	Δ	Y.
4.	Y.	Δ	Y.	Δ
5.	Δ	Δ	Y.	Y.
6.	Δ	Y.	Y.	Δ

The remaining four will not work in parallel, viz.:—

	Low Potential Side A	Low Potential Side B	High Potential Side A	High Potential Side B
7.	Δ	Δ	Δ	Y.
8.	Δ	Δ	Y.	Δ
9.	Y.	Y.	Δ	Y.
10.	Y.	Y.	Y.	Δ

For example consider case No. 8,—Low tension side in delta, and high tension side in "Y" and delta respectively. Then assuming the low tension sides already in parallel, and high

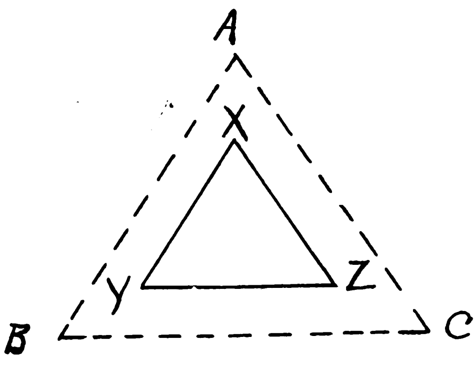


Fig 7

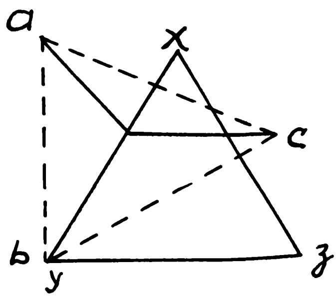


Fig 8

tension sides open, the phase diagrams are as follows, where A B C, *a b c*, represent one bank, and X Y Z, *x y z*, the second bank (see Fig. 7).

Then if *b* and *y* be joined on the secondary side, serious displacement voltages occur between *a* and *x* and *c* and *z* (see Fig. 8), and if these terminals are connected, these displacement voltages will cause heavy short circuit currents and destroy the transformers.

COAST LINES AND ENGINEERING

WILLIAM G. VINAL, '06

We are in the midst of tremendous transformations along the coast. Always the stage where Nature has played most dramatically, the shore is now the seat of the greatest engineering victories that the world has ever seen. San Francisco is spending nine million dollars on her harbor, and Halifax has appropriated twelve million dollars for the same purpose; large dry docks are to be constructed at Quebec, Cape Breton, and Esquimalt; municipal docks have been built at Houston, New Orleans, Mobile, Pensacola, and Los Angeles; fifty square miles are being reclaimed from the Bayou Barataria, near New Orleans, by drainage. The dredging of bays, the fortification of ports, the achievements of sanitary engineers, and the greatest triumph of all—the Panama Canal—herald a new awakening and a new life for the engineer who plies his trade along the coast.

Other continents are equally prolific in developing their shore lines. At Pará, Brazil, a quay is being built out into the shallow mouth of the Amazon and the dredgings are to fill in between the wall and the shore. This will give a thirty foot channel which will allow large steamships to unload their cargoes at Pará, sixty-five miles from the ocean. In Europe it is proposed to build a railroad from Dover to Calais by means of a tunnel designed by Simon Lake. His plan embodies the construction of tubes on land and sinking them in a trench on the bottom of the English Channel. The tunnel will thus be buried just beneath the surface and not further down as originally planned. Many cities might be mentioned such as Hilo, Hawaii; Hamburg, Germany; and Madras, India; which are trying to keep pace with the ever-increasing demands of commerce. Each one of these projects bears a direct relation to the destructive work of the sea or to its manner of transporting and depositing the waste of the land.

Geological forces sculpture and fashion the shore line today in the same way that they did in the past and it is fair to infer that these "past performances" may be expected in the future. The engineer who works in coöperation with these natural agents saves many dollars in the cost of the project. It is not the object of the present article, however, to deal so much with the "earning" as with the "living." It is to help those engineers who are "earning a living" by the sea to enjoy the work more fully by knowing some of the interesting activities of the most forceful and possibly the most consistent engineer, the ocean. Two illustrations, however, will show that such knowledge is oftentimes most practical.

The story of how the Mississippi River was made to build its own jetties shows the control of brain over brawn. These jetties were planned and constructed by James B. Eads to enable large boats to go up the Mississippi River. It is well known in geology that the narrower a channel the greater the velocity of the water which passes through it and, secondly, the swifter the current the greater the amount of erosion. It was upon these two laws that Eads carried out his plans successfully. The first problem was to confine the river to a narrow bed. Rafts of twigs were sunk on each side of the channel far out into the Gulf of Mexico. These twigs checked the speed of the current which in turn resulted in the deposition of sediment. The river soon built walls on each side of its path and rushed through its narrowed outlet with such force that it scoured out the bars which had been impediments to navigation. This event opened the gateway to one of the greatest highways of trade in the world.

The Eads before the footlights of today is Carroll Livingston Riker, an American hydrographic engineer, who has outlined a plan to build a jetty off the coast of Newfoundland to deflect the Labrador Current seaward. This would give the Gulf Stream full power to steam-heat the Atlantic seaboard as far north as the Grand Banks. Such an accomplishment would also prevent the too-far-south migration of the icebergs which are a menace to navigation. There is a further possibility of checking the

immense fogs in this latitude caused by the meeting of these unequally tempered streams. These changes would affect the border of a whole continent.

Shorelines may be divided into two classes, viz., the elevated and the depressed. To understand these changes we must know that the earth is cooling, shrinking, and folding much after the fashion of a baked apple. These movements of the earth's crust cause the coast land to emerge in some places and to be submerged in others. The elevated shore line takes on the characteristics of the sea bottom, which is smooth and even. Should a hilly coast be depressed it would produce an irregular shore line, the valleys becoming bays and the ridges forming headlands. Such a coast line is likely to have good harbors and is well adapted to commerce such as in northeastern United States and in Europe.

In regions where a coastal strip has emerged from the sea the problem of commerce is a great one. The engineer has to plan an artificial harbor such as at Vera Cruz or Madras. The recent increase of the demands of the temperate zones for the products of tropical lands will naturally lead to the building of more artificial harbors as the coasts of countries of the warmer belt are regular and shallow. Along with the development of a north and south trade will come the construction of commercial outlets in Mexico, South America, Africa, and India.

The elevated shore passes through characteristic changes. The waves beat up the sand into reefs which form some distance from the shore and become troublesome to navigation. If the tide is very strong inlets are maintained between the reefs, whereas in other places, such as Galveston, the cities have to migrate to the reef in order to keep in touch with sea traffic. When the crest of the sand appears above the surface of the water it is dried and then the march of the land is taken up by the wind. The wind drives the sand into the shallow lagoon between the reef and the mainland and the invasion of vegetation follows closely. If this process is allowed to continue the area becomes a salt marsh. In the mean time the sand reef

has been yielding to the attack of the waves and the shore line has migrated across the marsh to the cliffs of the mainland.

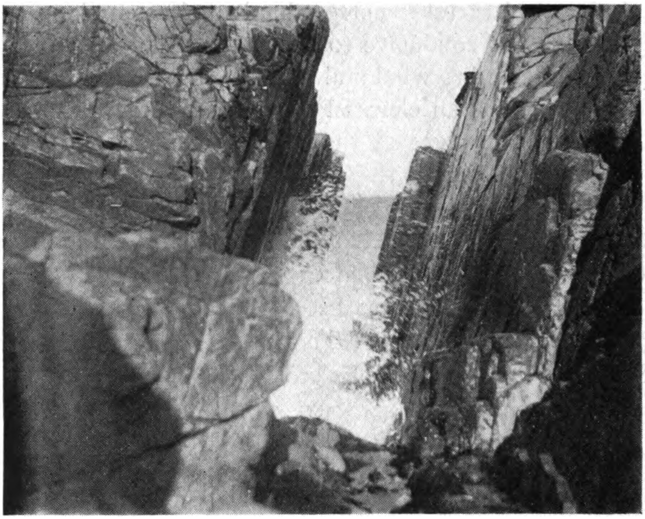
It would appear impractical then to build a city upon shifting sands. Such has been the experience of many cities along the coast from New York to Texas. The persistent effort of the sea to build sand reefs in youth, to fill in the resulting lagoons and then to keep up the vigorous attack until the mainland is reached means the expenditure of large sums to develop and maintain the harbor and the city. Pilots are needed to guide the vessels across the shoals, the harbors have to be constantly dredged, the sand island is not productive of vegetation, the low marshy area is not conducive to health, and the offshore border is constantly exposed to wind and wave. The originator of a new city or project along an elevated shore should know and be able to appreciate the changes of the past and those to be expected in the future.

The submerged coast is modified by waves and currents. The headlands are exposed to their attacks and when made of gravel retreat more rapidly than when of rock. Heligoland, an island off the coast of Germany has been reduced to less than 5% of its area a thousand years ago. The force of the waves is terrific. Concrete blocks weighing four tons each were swept away from the breakwater at Cherbourg, France, in one storm. On rocky coasts fragments weather from the cliffs and fall to the bottom. These weapons are gathered up by the waves and hurled at the base. A large notch is cut at the base and this undermines great masses from above to be used in pounding the parent rock. Some day the engineer may conceive a plan of harnessing this great energy of old Neptune and make it useful for man.

The architecture of the sea cliff is most interesting. The waves carve a notch into the ridges of the land, the bottom side of which forms a bench. Like a skillful sculptor the sea etches out caves and arches. These cavities are drilled near a joint or wherever the rock is weak. If the sea forces its way back of a portion of the cliff a stack or monument is formed. All

these forms of the cliff testify to the retreat of the land before the attack of the ocean.

The waste material at the base of the cliff, under the action of the shore current migrates along the coast to form beaches. The pebbles are ground and crushed into sand and finer waste so that the material of the beach becomes finer as the distance from the cliff is increased. Sometimes this drift material is swept to the head of a bay where it forms a so-called bay-head beach. More often the roadway of drift is across the mouth



The Churn at Marblehead, Mass.

of the bay. If this bridge is incomplete it is called a spit, such as found at Provincetown, Barnstable, and Plymouth Harbors. These spits tend to choke the entrance to the harbor. At Nantucket, Massachusetts, jetties have been built to maintain an open door. These beaches have formed a complete embankment across the former bays of southern Rhode Island and of southern Martha's Vineyard. These barrier beaches often form the basis of a road and in some places they are completed by the building of a roadway such as at Devereux Beach in Marblehead.

The former bay now becomes a lagoon which grows shallow as the winds and rains deposit material in it. The filling of the lagoon encourages the invasion of reeds and grasses. In time this pond becomes a marsh after the same fashion as the formation of the marsh back of the sand reef. The waves keep on cutting back the promontories and barrier beach until the shore becomes planed into a straight line resembling the coast of northwestern France.

Marsh construction behind a barrier beach at Scituate, Mass. The fourth cliff, in the distance, marks the new mouth of the North River, which was made in the November gale of 1898. The old mouth is several miles from this point.

The straightened shore, like the elevated coast, is unfavorable to commerce. The problem of making an artificial harbor is the same as that along the lowland coast. Dover, England, has a forty-foot harbor, a mile square, enclosed by a series of breakwaters which cost more than twenty million dollars. The importance of shore line improvement is made clear when such large appropriations are made to protect shipping.

The natural changes between the land and sea make it evident that work along the coast will never be complete. In 1737 there were no aids to navigation in New York Harbor and now there are two hundred and sixty-eight. The modern equipped shore not only shows how the problems of the past have been solved but illustrates that successful operations have been carried out with the systematic workings of Nature. Engineering is lending a hand as never before in directing the power of the ocean and in the development of world commerce.

In the same way that the border of the sea has always been a line of inspiration to the traveler,—to the Columbus of old as well as the tourist of today,—it marks a line of achievements and hopes for the young engineer. With the thought that the edge of the land has been attacked by the unhampered sea ever since the lands appeared, and that within a generation the rolling waves and changing tides have already been harnessed and controlled to the extent described, he may well dream of great and untold accomplishments in the future.

THE HARVARD MINING CAMP

W. S. WEEKS, '06

The Harvard Mining Camp is situated among the hills of Vermont in the little village of South Strafford.

"But," you will say, "are there any mines in Vermont?"

When George Washington was inaugurated President of the United States for the second time, a discovery of weathered pyrite was made on Copperas Hill. The natives at first thought

The Camp

that a valuable iron mine had been found, so they took some of the ore to an iron furnace at Franconia, N. H., and mixed it with some of the Franconia ore. The result was a mixture of iron and sulphur called iron matte and, so history tells us, "the furnace was blocked up and no more ore could be smelted therein till the sulphurous mass was removed, which was done at great expense."

Later developments proved the deposit to be a copper mine and many tons of ore have been extracted. At present the property is owned by the Vermont Copper Company and it is by their kindness that we have the opportunity of using the many openings for mine surveying and practical mine work.

The camp is entirely of canvas, and nestles in a green meadow which slopes away toward the valley of the Connecticut.

The life during working hours is made as nearly like the actual life of the miner as possible. The men work an eight hour shift from seven until four with one hour for dinner.

Now a method of mining is nothing more or less than the combining of various small operations in various ways to suit particular conditions. So it is the aim of the camp to teach the student enough about these smaller tasks to enable him, when he enters the higher courses which deal with the broader aspects of mining, to visualize and understand the more complex operations. To this end the work is divided into three parts—surveying, machine-drilling, and what the boys have termed "general housework." Each man spends two weeks in each of these groups.

The surveying is in charge of an assistant and he runs his squad like a regular mine corps. The surveyors are not subject to the rigid hours of the "miners." It is a perennial joke for a well-washed surveyor to stand beside one of the dust and smoke begrimed boys who is at mine work and ask, "Which is the educated man?" But the immaculate engineer of today is the "miner" of tomorrow, and the joke never grows old.

The machine work consists of drifting and stoping. This work is in charge of experienced miners and the art of breaking rock is well taught.

The "general housework" is also in charge of miners and consists of hand drilling, track laying, timbering and other small operations. The greatest casualties occur in the hand drilling, for there are no gloves thick enough to withstand the onslaught of a burly athlete with a six-pound striking hammer. The quiet stoicism that pervades this work is well illustrated by the following incident. The man holding the drill had been struck

twice with the hammer and demanded a turn at striking. The man who had been striking sadly yielded up the hammer with these portentous words, "Justice must be done!"

And so it goes through six weeks of steady work, each day of which brings the student into closer contact and understanding with the kind of work and the kind of men with which he has cast his lot. And we feel satisfied if he has learned the dignity of a day's work and has learned to look with respect on the

The Mine and the Smelter

man, whatever his station, who does well the task he is expected to do. And we are more than pleased if perchance he may find a little of nobility in the work of rending the solid rocks that the wealth of the world may be increased, for

It's granite and slate, and it's trap and it's clay
Fighting and fighting to keep us away;
So we drill and we blast, and we labor and plan
To render the ore to the service of man.

THE MERIDIOGRAPH

LOUIS ROSS, '03

I. General Description.

The Meridiograph is a new instrument for surveyors and engineers to determine an accurate meridian. With its aid a true north can be located in a few minutes, nearly all day, to an accuracy of 1′ or 2′, without attachments, computation, books or knowledge of astronomy. It is only necessary to measure the sun's altitude, and set the data on the Meridiograph, as on an ordinary arm protractor,—which gives the accurate bearing of the sun from the *true* north. To the young surveyor and civil engineer finding a true meridian is the most important astronomic problem. The survey of U.S. lands, boundaries, mines, railroad and canal lines must all be referred to the true north as a reference line. Even where not required, the true north is still the surveyor's best possible—almost indispensable—check on the accuracy of his line work.

Nearly all methods available are heavily mathematical, or they require considerable physical effort and very costly surveying time, or else depend on attachments which interfere with regular transit work and whose complex adjustments cannot be relied on in the field. Because of these difficulties, lines are not checked astronomically with sufficient frequency and any errors found are "fudged," or else the work has to be done over again. The writer has known, in his experience, of cases where the color-blindness of a rear rodman has caused him to mistake the back azimuth mark, and thus vitiate two weeks' work, which cost some five hundred dollars to repeat.

These difficulties, experienced during a number of years of field work, have led to the production of the Meridiograph. Any one who can read an angle can find, with its aid, an astronomically true north, in a few minutes, twice or oftener daily, with certainty. The Meridiograph solves graphically the problem of

finding a true meridian by the sun; and will also give, if desired, the accurate apparent local time, or longtitude. Auxiliary diagrams with explicit directions are provided for obtaining and reducing the necessary data. This is all non-technical, requiring neither the use nor the knowledge of astronomy or mathematics.

The Meridiograph, as seen from the photograph, Fig. 9, consists of two circular scaled discs of 7 inches maximum diameter with a reading arm. The names of all scales are on the arm, exactly over the graduations;—this obviates searching for any desired scales. Nearly all graduations are 5′ or 10′ spaces; angles may therefore be read to an accuracy of 1′.

The scales, beginning with the outermost, are:—

NUMBER .10 to 1.00, complete circle, for numbers A, B, (A + B).

BEARING 20° to 88° 40′ approx. 1 ⅔ loops, for true bearing of sun.

b	10° to 60°	approx.	¼	loops,	for either alt. or lat.
a	10° to 60°	"	1	"	" " " " "
a	10° to 60°	"	1	"	" " " " "
b	10° to 60°	"	¼	"	" " " " "
DECL.	1° to 23° 30′	"	1 ⅓	"	" declination.

To find true north, measure sun's altitude, take its declination from the Ephemeris, and latitude of station from a map. Set these data on the Meridiograph, by means of the reading arm, thus:—

On scales *a* set altitude against latitude, opposite index read number A.

On scales *b* set altitude against latitude, opposite given declination read number B.

Opposite (A + B) read *true* bearing of sun.

The transparent celluloid cover, which may be seen in the photograph with the three finger slots, has been devised to serve the double purpose of protecting the scales from wear and soiling, and also to prevent the discs from moving accidentally, after they have been set on a given reading.

2. Field Procedure.

DATA required to obtain true north is LAT., DECL. and ALT.,—all correct to 1′ of arc.

LATITUDE of place take from any accurate map. If not available, measure at noon sun's altitude, H; then, if decl. is north $L=90°-H+D$; if decl. is south $L=90°-H-D$.

DECLINATION of sun, for every day in the year, with its hourly change (+ or —) is given in the Ephemeris, for Greenwich noon. Apply the "Change in decl. since Greenwich noon" from Fig. 1.

ALTITUDE of sun measure, also its bearing from any fixed line. Subtract refraction, as given in Fig. 2.

RECORD DATA in note book, in the form shown by Fig. 3. With the Meridiograph find values of A, B, and hence TRUE bearing of sun. From the assumed fixed line locate TRUE NORTH, with the aid of Fig. 4. If there is any doubt about the quadrant, consult Fig. 5.

MOST ACCURATE RESULTS will be obtained in the early forenoon or late afternoon. When sun's altitude is 15 to 25° result is best, 25° to 35° fair; over 45° poor. Between 10 A.M. and 2 P.M. results are unreliable.

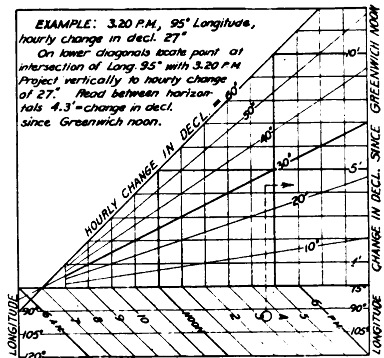


FIG. 1

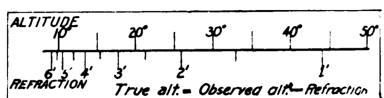


FIG. 2

Lat of sta.	L =	A = +	
Alt of sun	H =	B =	0.
Decl. " "	D =	(A+B) =	0.
Hence true bearing of sun =			

FIG 3

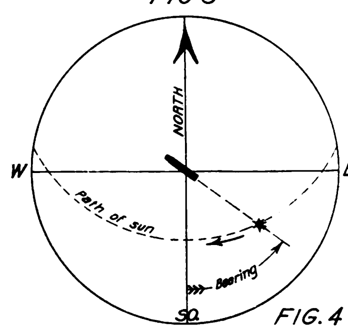


FIG. 4

If (A+B) is	+	—
In A.M. sun is	S-E	N-E
In P.M. " "	S-W	N-W

FIG. 5

The apparent local time or longtitude may be obtained at the same time, to an accuracy of ½ min. of time by a single setting, thus:—

On scales *b* set alt. against (90°-bearing),
Opposite decl. angle read time angle, t°.

App. local time is $\left(6 + \frac{t^\circ}{15}\right)$a.m. or $\left(6 - \frac{t^\circ}{15}\right)$ p.m.

All readings are made on the *b* scales only, in *any* order. Thus:

Let sun's alt. = 30°	**Set 30° against 40°, both or. scales *b***
" " bearing = S50° W	**Opposite 15° read 47°40′ " " " "**
" " Decl. = 15°	**App. local time is 6—3h. 11m.=2.49 p.m.**

This feature is especially convenient in surveys at a distance from railroads, as it makes the surveyor independent of a watch, and also obviates the mathematical reduction of standard clock time to apparent local time.

3. THEORY.

Figs. 6, 7 and 8 will refresh in the reader's mind the physical concepts and factors involved in solar work.

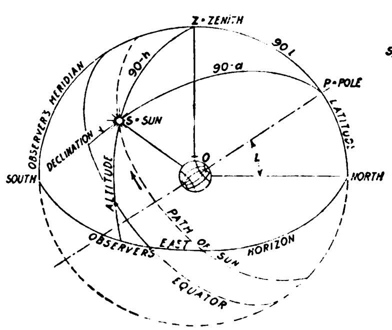


FIG. 6

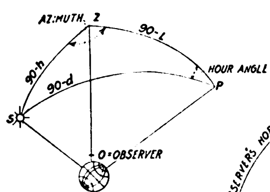


FIG. 7

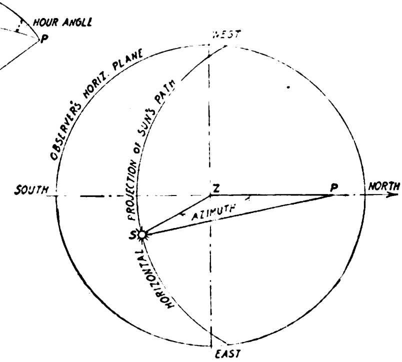


FIG. 8

In Fig. 6, *O* is the position of the observer, who, having his zenith Z vertically above him, is more intelligibly conceived of as being situated "on top" of the earth; directly north, at an altitude equal to the observer's latitude, is the celestial north pole *P;* while to the south is the sun *S*, shown as it would appear on a summer morning, north of the celestial equator and bearing

southeasterly. The relative size of the earth has been exaggerated in the sketch for the sake of clearness. Fig. 7 shows more clearly the azimuth Z, the quantity principally discussed in this article, projected on the horizontal plane in which the transit measures horizontal angles.

The general procedure is to measure the sun's altitude h, obtain from the solar ephemeris its declination d, and take from a map the observer's latitude L. These three factors are substituted in an equation of the form

$$Cos\ \tfrac{1}{2}\ Z = \sqrt{\frac{sin\ \tfrac{1}{2}\ s\ \ .\ \ sin\ (\tfrac{1}{2}\ s - (90\ d)}{sin\ (90 - h)\ \ .\ \ sin\ (90 - L)}} \qquad (1)$$

where

$$S = (90 - h) + (90 - L) + (90 - d) \qquad (2)$$

from which Z, the sun's true azimuth, is computed.

The solution of this equation in the field is impracticably difficult and liable to error. The equation is therefore replaced by one more simple in form.

The fundamental cosine law of spherical trigonometry gives the equation.

$$\begin{aligned} Z &= cos^{-1}\ (A + B),\ \text{where} \qquad (3)\\ A &= \tan h \times \tan L\\ B &= \sec h \times \sec L \times \sin D. \end{aligned}$$

The two scales a are logarithmic tangents, plotted on the number scale as a base, but reversed with reference to each other. Setting any two angles on these scales opposite each other gives the product of their tangents on the number scale. Likewise, scales b are logarithmic secants, one of them reversed, while the DECL. is a sine scale. When three angles are set on these scales, the last one falls opposite the product of the secants and sine, giving the value of B. The BEARING scale is a cosine scale, which gives the final answer.

The value of A, B, and (A + B) will nearly always lie between .10 and 1.00, as given by the decimal point of the number scale. The exceptions, especially within U.S. latitudes, are rare.

Those familiar with the slide-rule will readily grasp the method of handling these rare cases. For those not familiar with the slide-rule brief, explicit directions are provided to cover every possible contingency.

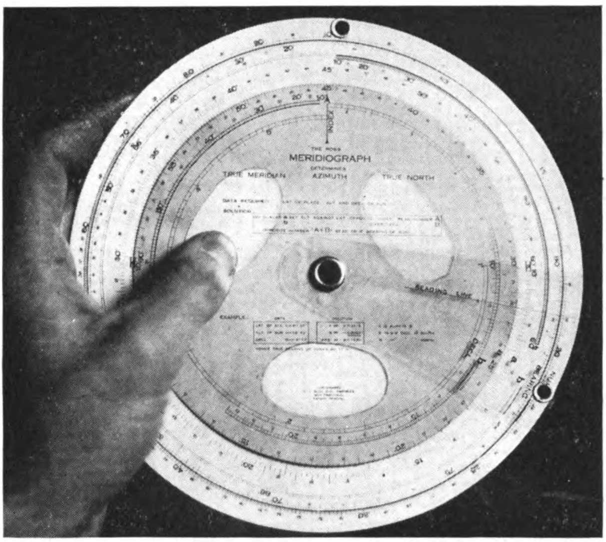


Fig. 9
The Meridiograph

4. Accuracy.

Though the maximum diameter of the discs is only 7 inches, the angular scales are as open, on an average, as those on an ordinary protractor of about 60 inches, or 5 feet, diameter. Thus: $22\frac{1}{2}^\circ$ of declination occupy $1\frac{1}{3}$ loops, or 480° of actual arc, giving an average enlargement of 21; likewise, 70° of bearing occupy about $1\frac{2}{3}$ loops, giving an average enlargement of $8\frac{1}{2}$. This most desirable effect has been attained by a suitable arrangement of logarithmic scales, and shows the fallacy of using mechanisms of watch-like fineness, with a multiplicity of axes, verniers, and complex adjustments, such as are used in the solar attachment in place of applied mathematics.

The accuracy of the Meridiograph keeps pace with the accuracy of the observation, being more accurate in the early morning or late in the afternoon, and least accurate toward noon. To prevent the unitiated from taking observations between 10.30 A.M. and 1.30 P.M., bearings from 0° to 20° have been omitted altogether from the scales.

The theory of construction of the Meridiograph carries no approximation. Nearly all graduations are 5′ or 10′ spaces, so that angles may be read to an accuracy of 1′ without difficulty. The mechanical centering of the discs is tested to an accuracy of about one half minute. The only other possible source of error is the user's inexact reading of the numbers A, B. An allowance of 1′ to 2′ in accuracy, depending on the time of day, has been made in the description of the Meridiograph, to allow for inexact readings. The sufficiency of this allowance has been checked by actual test, on some fifty different sets of data.

EARTHQUAKE PROOF CONSTRUCTION*

J. H. RIPLEY, '14

The simplest understanding of an earthquake is a yielding to stress, during which period the ground is transversed by swiftly moving waves causing permanent distortion. By means of the seismograph rough zones of seismic disturbance may be approximated and due precautions taken in construction in the vicinity. The seismograph, besides being instrumental in determining the zones of safe building, can also be used to show the results of shocks on buildings, considerable work of this kind having been carried out by Professor Omari in Japan.

In the latter country considerable efforts have been made to perfect the resisting powers of wooden buildings against shocks from quakes. The main point reached was that metal straps should be employed for fastening all outer corners, and that pillars should not be cut at places where doors are desired.

From a study of the effects produced on various types of buildings in the San Francisco Earthquake several important facts were determined. The wooden houses only suffered from the falling of chimneys. The damage on steel structures where the walls supported the floors was much greater than where the steel wall columns supported them. The reinforced concrete structures suffered very slightly and only in the case where the foundation was on alluvial soil.

In conclusion it must be noted that the exact amount of the quake stresses cannot be pre-determined; a rough theory is that a building which can withstand 30 lbs. per square foot wind pressure is sufficiently strong. The main principle we must look for is elasticity. A well designed steel frame offers the best solution for an earthquake-proof building and a wooden frame building is very adequate.

---

* Summary of a lecture delivered before the Harvard Engineering Society on January 23, 1914.

HARVARD ENGINEERING JOURNAL

A Quarterly

DEVOTED TO THE INTERESTS OF ENGINEERING IN HARVARD UNIVERSITY

THE OFFICIAL ORGAN OF THE ASSOCIATION OF HARVARD ENGINEERS

Published four times during the college year by the Board of Editors of the Harvard Engineering Journal in November, January, April and June.

Subscription Rates

Per year, in advance $1.00
Single copies 35

Advertising rates will be furnished on application to the Business Manager.
Address all communications to the heads of the respective departments:—

Harvard Engineering Journal,
Room 218, Pierce Hall,
Cambridge, Mass.

Entered at the Post Office, Boston, Mass., as second-class mail matter, June 5, 1902.

On January 9, 1914, an agreement was ratified between Harvard University and the Massachusetts Institute of Technology to coöperate in their work in Engineering and Mining. This plan, if carried out in the broad and generous spirit of its beginnings, will not only eliminate competition between the two

institutions, but will also provide opportunities for technical education and research such as neither institution alone could hope to offer.

This agreement covers the work of the present Harvard Schools of Engineering and of Mining, and the four Institute departments of (1) "Civil and Sanitary Engineering," (2) "Mechanical Engineering, Applied Mechanics, and Mechanic Arts," (3) "Electrical Engineering," and (4) "Mining Engineering and Metallurgy." When the new Institute buildings are ready, Pierce Hall and the Rotch building, the present quarters of the Harvard Schools, will be given over to other departments of the University; and both institutions will unite in supporting and promoting education and research in the four departments named in one great school, on the Riverbank in Cambridge.

The other Schools of Applied Science in the University, Architecture and Landscape Architecture, Forestry, and Applied Biology, and the pure sciences, are not included in this agreement, nor, on the other hand, are departments of the Institute other than Engineering and Mining. Such opportunities for the study of applied science as are now open to undergraduates in Harvard College, as part of a general education, will not be diminished; courses in drawing, descriptive geometry, surveying, generation and transmission of power, electricity and mechanics will be continued in the undergraduate departments of Engineering Sciences and Physics in the College.

The name, organization, and property rights of the University and of the Institute will not be affected by the agreement. The President of the Institute reporting to both Corporations will be the executive head for the combined work; and when any future President is appointed, the President of the University is to sit with the committee that recommends the appointment. Income of all funds held or that may be acquired by both institutions for work in Engineering and Mining, students' fees in these courses, and such additional sums as each institution can spare from other funds, will be devoted to the coöperation. The University will contribute at least three-fifths of the Gordon McKay

Endowment. The only restrictions as to the use of funds are that money supplied by the University shall not be used for the erection of buildings on land that does not belong to the University, that each Corporation shall vote all appropriations of its own moneys, and that appointments of teachers shall be made by the Corporation that pays their salaries, after consultation with the other Corporation. All expenditures under the agreement are to be made through one agency, the bursary of the Institute. The laboratory equipment of both institutions will be combined in the new Institute buildings; and the high tension laboratory adjacent to Pierce Hall, now nearing completion, will be equipped for joint use by the great department of Electrical Engineering, created by coöperation, and the department of Physics of the University. The Harvard Camp at Squam Lake, and the Technology Camp at East Machias, will probably both be continued. In short, the plan contemplates the most efficient use of all available resources of both institutions.

The work of instruction will be in charge of a faculty composed of the members of the Institute Faculty and of the professors, associate professors and assistant professors of Mechanical, Electrical, Civil and Sanitary Engineering, Mining and Metallurgy in the University. This combined faculty, numbering about one hundred and twenty professors, will make recommendations for all degrees to be conferred by both institutions under the agreement. All Harvard professors retain their rank and privileges in the University; and all professors, associate professors and assistant professors of these branches now in the Institute, acquire similar titles and corresponding privileges in the University. Likewise all future appointments of similar rank in these branches, made by either Corporation will be officers of both institutions. This remarkable group of professors in Engineering and Mining, now about fifty in number, who will be all Technology men and at the same time all Harvard men, constituting the four departments named, will have direct charge of the combined work; they will give all the technical courses, and supervise the programs leading to degrees in these departments. It is stipulated that each Corporation may lay down the conditions

under which its own degrees will be granted, although it may safely be assumed that these conditions will be identical for both. Graduating students in Engineering and Mining will receive diplomas both from the University and from the Institute, and will be entitled to all the rights and privileges of alumni of both institutions.

The arrangement of courses leading to degrees, will, under the coöperation, follow in general the plan now in force at the Institute, that is, four-year undergraduate courses, leading to the degree of bachelor of science, and open on examination to students who have completed a good high-school course or its equivalent, and open also to students coming from colleges with an academic training, who may enter with part of the four-year courses fulfilled. There will be advanced courses of specialized study and research leading to higher degrees, and open to graduates of the four-year courses, and to graduates of other technical schools. The Harvard Schools of Engineering and Mining at present admit only graduates of colleges and scientific schools; in the future the University will participate in professional technical instruction for both undergraduates and graduates.

Both institutions will generously support the work, and both will be vitally interested in the welfare of the school. The teachers and students and future graduates in Engineering and Mining will be Technology men, and at the same time Harvard men with all the privileges of two great institutions, and loyal to both. Behind the plan will be the alumni of both institutions united to develop one school unrivalled in prestige and usefulness.

From any standpoint the agreement is a remarkable achievement; from an institutional point of view it is revolutionary. Educational rivalry is commonly deemed commendable at any cost. Since the first attempt at coöperation between these two institutions was made over forty years ago, various negotiations have failed, chiefly because of the deep-rooted belief of both schools in their right to independent success. At last two great schools, each with funds, staff, prestige, and loyal alumni, such as would ensure its own continued prosperity and usefulness, have

agreed to forego the satisfaction of independent success, and to use the funds entrusted to them for the best good of the community and the cause of education.

HECTOR J. HUGHES,
Chairman of the School of Engineering of Harvard University

The recent agreement between Harvard and Technology is set forth in a brief document which is accessible to all, and its main points are easily singled out. It is an agreement between independents and does not involve in any sense an absorption of one institution by another. No change whatever is made in the constitution of either corporation, and no change in the powers of either, and no limitation of those powers except what is necessarily involved in the idea of coöperation. Each party retains absolutely the control of its own funds and each is free to make any regulations that it likes with reference to the degrees that it will give and the courses of instruction leading to those degrees.

How will this agreement affect the work of the two institutions? In one sense, very little. It will be observed that it involves no giving up by either party; all that is now done by either will continue to be done, the difference being that it will be henceforth done by *both*. There has been some talk about Harvard giving up its graduate schools. How can she be said to give them up, when she is joining forces with Technology which has long had by far the largest graduate engineering school in the country? Harvard has been in the field of engineering longer than Technology, but it is only within recent years that she has emphasized the graduate idea by making graduation from a college a condition of entrance to her schools. One reason for her doing this must have been that with limited resources she wisely deemed it better to do one thing and do it well than to attempt many. Doubtless, too, she could confine herself to college graduates with more satisfaction when she recognized that only across the river was another institution that had long been

catering and catering well for the high school graduate whose time or means or both were limited. Technology has always paid special attention to these men, and no one in authority has suggested that she should now change her policy in this respect, and needless to say, she has no thought of so doing. But she has never taken a narrow view of her duty, her policy being always to do the best that she can for all sorts and conditions of men, whether college graduates or not, provided that they measure up to her standards at entrance. Harvard's alliance with Technology will make possible a more effective provision for the needs of graduates of high schools who seek to enter the enginering profession; it will also make possible a more effective provision for the needs of the college graduates. Its special advantage, as I see things, is that it will make possible a far more effective provision than is made anywhere in this country for the needs of another class—those men small in number but great in power and influence, who are prepared to devote themselves to advanced study and research in engineering. We lag far behind some of the older countries in this respect, although we have made wonderful strides in recent years. Great corporations in various parts of the country are building up research laboratories and richly endowing them, but there are thousands of smaller concerns that do not see their way to do this. By means of this combination, I see built up in due time a great clearing house for the solution of countless problems in manufacture and industry. To this great centre men who have had the necessary training will come from all parts and will find there a splendid equipment of men and of machinery, and an invigorating atmosphere of hard work. With this equipment and in this atmosphere investigations of various kinds will be conducted on behalf of municipalities, corporations and individuals, the spirit of research will be greatly encouraged and a splendid engine will be maintained at a high standard of efficiency for the advancement of science that is applicable to the service of man. It will be an enormous advantage to have all this varied work going forward at the same time and in the same place and under the supervision of the same men. Each branch will stimulate

the other and the whole will be vastly more effective than if the different parts were isolated or apart. The conditions of work will be well-nigh ideal for the ablest teachers, the ablest investigators and the ablest students, and with proper support from the country as a whole, this institution will stand before the world unrivalled in its power and influence for good.

I have heard some talk occasionally about the difficulties that will arise from an alliance between two institutions whose educational ideals in the realms of engineering are different. Such talk comes mostly from those who are ignorant of one or of the other or of both these institutions. Sometimes it revolves around the distinction between the graduate and the undergraduate ideal, in ignorance of the fact that Technology is a great graduate school and that both institutions have had experience in dealing with graduates and undergraduates alike. Sometimes it is suggested that Technology is a narrow school devoted to so-called "practical" pursuits and with no vision beyond what are styled "bread and butter" studies. This is contrasted with Harvard's "culture." All such talk is mere ignorance beating the air. We are sure to miss the mark if we fix our eye either on graduate or on undergraduate, on practice or on culture. The importance of such distinctions can be greatly over-estimated. Culture without practice is a sham, and the graduate and undergraduate have much to learn from one another. If we go to the root of the matter, we see that in engineering education, Harvard and Technology are imbued with the same great ideals, —the ideals of thoroughness and of breadth. The great charter of the Institute is set forth in clear language in the "Objects and Plan" of its founder, President Rogers. In that charter he emphasizes the importance of being useful and practical. But he takes care to guard against a narrow use of the dangerous word "practical." "We believe," he says, "that the most truly practical education is one which unites with habits of close observation and exact reasoning a large general cultivation." The Institute has always striven to be true to this ideal of its great founder, and in the opinion of students of its history, its success has been largely due to this very fact. A study of litera-

ture, of history, of economics, of languages, as well as much study of pure science, enters largely into its curricula, just as largely, indeed, as the time available for study makes possible. The ordinary Tech undergraduate covers about as much ground in these matters as does the ordinary college student, although he covers it more rapidly and has to work with more purposefulness and greater intentness so to do. It may be that not many know this, and that one result of the alliance between Harvard and Technology will be to draw attention to the important fact that a broad general cultivation is the very essence of Technology's scheme of education for the engineer. Certainly, such an education is needed more today than ever, for more and more will the engineering profession call for the well-rounded man as the standards of the profession rise, and as those that practice that profession take their proper place in the life of the community, not only as engineers, but as public-spirited citizens.

It can scarcely be necessary to attempt an enumeration of the advantages that a school conducted by the two institutions will have over what either institution alone could have maintained. Most of the advantages are obvious. The combination of financial recources and the combination of faculties means a great saving of money and of men. Both of these things are important today. We cannot neglect financial matters when the cost of educational living is so high. The saving in men is, however, still more important. There are not nearly enough good men to go around, far less to waste. Apart from these things, one of the most obvious advantages is the gain in attractive power on the ablest students and the ablest teachers, and the gain in the goodwill of a united community. Many factors go to the making of a great school, but the essence of the whole is to have good students, just as without good grain you cannot have good flour. I need not dilate on the attractive power of this school of engineering which will open to its students in their undergraduate days the resources of two great institutions and give them in later life all the advantages that will come from con-

nection with a great university and a great technological school. That cannot fail to make it attractive to able and ambitious youth everywhere. Today each institution separately attracts bright young men from all parts of the world. The fame of Harvard is heard in every quarter of the globe. Its younger sister Technology began as a local institution, drawing small numbers from a restricted area. It attracts now in large numbers from every state in the Union, and draws men from foreign parts more than twice as powerfully in proportion to its numbers as does any other institution of learning in the country. In combination with Harvard its attractive power for bright men from all parts of the world will be well-nigh irresistible. It is important to note that it should be equally attractive to able and ambitious teachers. Such men want to be where there are bright students in sufficient numbers to make their influence felt in later life. However attractive you make a professorship in other respects, if it lacks this, it will not, except in rare cases, attract men of the right type. A combination that gives an institution a large share of the best students and a lion's share of the best teachers can scarcely fail to exercise a powerful influence on the engineering of the future.

RICHARD C. MACLAURIN,
President Massachusetts Institute of Technology.

The HARVARD ENGINEERING JOURNAL completed, with the January, 1914, issue, its twelfth year of successful service to the Engineering community of Harvard. It has witnessed many changes in environment, most notably the discontinuance, seven years ago, of the Lawrence Scientific School, and the organization of the Engineering School as one of the Harvard Graduate Schools, but for twelve years the JOURNAL itself has remained practically unchanged, keeping closely to tradition, and following out carefully the ideas of its founders. With the carrying out of the new agreement for coöperation between the Harvard Engineering School and the Massachusetts Institute of Technology,

the far-reaching effects of which have already been discussed, the HARVARD ENGINEERING JOURNAL will face the problem of including within its sphere of service the new class of engineer, the product of the combined schools, whose interests will include at once both Harvard and Tech. Here changed conditions suggest the modification of JOURNAL traditions, and the institution of such changes in form and method as are in harmony with the broadened interests of Engineering in Harvard University.

With this end in view, arrangements are under consideration for the combination of the HARVARD ENGINEERING JOURNAL and the *Technology Monthly* into a single monthly magazine, which will aim to interest the undergraduates, graduate students, and graduates of the combined Harvard-Tech school, and the present graduate bodies of both Harvard and the Institute. The scope of such a magazine will necessarily be wide. The new paper, *The Technology Monthly and Harvard Engineering Journal* by name, will include articles on current events of interest to both Harvard and Tech, short stories, technical articles by graduates, members of the staff of the combined school, and practicing engineers, and editorial sections where will be gathered reports of graduate and undergraduate associations and societies, the official notices of the Association of Harvard Engineers, and complete notes of the doings of graduates, arranged by classes. Thus while the new Monthly will adopt the size and shape of the present *Technology Monthly*, it will include all the essential elements of each of its component parts.

The *Technology Monthly and Harvard Engineering Journal* will appear monthly, eight times a year, from October to May, inclusive, probably beginning with May, 1914. The regular subscription will be $1.50 a year (eight issues), but to members of the Association of Harvard Engineers, $1.00 a year, thus making the price per issue to members the same as that of the HARVARD ENGINEERING JOURNAL, for which the rate to members was $.50 a year (four issues). All unexpired subscriptions to either the *Tech. Monthly* or the JOURNAL will be filled, until the date of expiration, by the combined paper. Advertising rates will be

slightly higher than the present JOURNAL rates, as befits the more than doubled circulation and larger page. All outstanding contracts with advertisers will, however, be fulfilled at the present JOURNAL rates.

Proper execution by the new monthly of its duties as official organ of the Association of Harvard Engineers will be insured by the presence as *ex-officio* members of the editorial board of the Secretary and Treasurer of the Association. Moreover, until the fusion of the Harvard Engineering School with the Institute becomes complete, it is agreed that either the Editor-in-chief or the Assistant Editor shall be a Harvard man. New editors will be selected from both Harvard and Tech on a competitive basis.

The plans above outlined were laid before the Council of the Association of Harvard Engineers, at its meeting of February 27 at the Boston Harvard Club, for consideration and criticism. The Council there formally approved all arrangements for the new monthly, and agreed to adopt it as the official organ of the Association, in the capacity at present filled by the JOURNAL. It was suggested that additional details relating to the merger be subject to the approval of the Secretary and Treasurer of the Association, who were given full authority to represent the Association in these matters.

The results to members of the Association of Harvard Engineers of this combination of the two representative Engineering periodicals of Harvard and Technology may be summarized as follows: Present subscribers to the JOURNAL will receive monthly, instead of quarterly, a magazine approximately twice the size of the JOURNAL, containing, among other things, a greater number and variety of technical articles, and an editorial section with Society and Graduate Notes which will be more easily and thoroughly kept up to date than at present by reason of the greater frequency of publication. Members may subscribe or renew subscriptions at $1.00 a year, thus obtaining the larger paper at the same rate per issue as the JOURNAL.

It is hoped that the new monthly may meet the approval and earn the support of the whole body of Harvard Engineering

graduates, both those who are present subscribers to the JOURNAL and those who are not, for with its larger body of contributors and wider range of appeal, the new paper cannot but interest strongly all Harvard graduates, including the small minority whom the JOURNAL has failed to attract. As its service to those who are still students, the monthly will hope, through the early joining of Harvard and Tech. interests in a single periodical, to bring about such unity of thought and mutual understanding that Harvard and the Massachusetts Institute of Technology may, thereby, come into more complete coöperation.

THE HARVARD ENGINEERING JOURNAL takes pleasure in announcing the election of the following men as active members of the Board of Editors:

JOHN RAYMOND TUTTLE, 1GS., of Syracuse, N.Y.
PHILIP STONE DONNELL, 1GS., of Wiscasset, Me.
WILLIAM BROWN CLARKSON, 1GS., of Brooklyn, N.Y.
WILLIAM CLAIR ATWATER, 1GS., of Beatrice, Neb.
THOMAS BUEL, 1GS., of New York, N.Y.
ANSON BLAKE GARDNER, 1GS., of New York, N.Y.

Tuttle and Gardner graduated from Yale University, Donnell from Clark University, Clarkson from Williams College, Atwater from Bellevue College, Neb.; Buel is a graduate of Harvard.

ASSOCIATION OF HARVARD ENGINEERS

A special meeting of the Council of the Association of Harvard Engineers, to consider the proposed combination of the HARVARD ENGINEERING JOURNAL and the *Technology Monthly,* was held at the Harvard Club on February 27.

It was voted to ratify the agreement reached by the Editors of the two publications and to make the new magazine, *The Technology Monthly and the Harvard Engineering Journal,* the offi-

cial organ of the Association, to be sent to members at a special subscription price. The secretary and treasurer of the Association are to be *ex-officio* members of the New Board of Editors, which is also to have, until the completion of the Harvard-Technology coöperation plan, members from both schools.

The following resignations from membership have been reported:

G. O. Carpenter.

W. A. Hedrick.

F. P. Huckins.

A. H. Patterson.

P. W. Whittemore.

Changes of addresses since the last issue of the JOURNAL are:

H. K. Craft, Care Commonwealth Edison Co., 30 No. Market Street, Chicago, Ill.

Franklin Remington, The Woolworth Building, New York City.

P. D. Hawkins, Middlebury, Vt.

C. A. Sargeant, Gorefield, Saskatchewan, Can.

Lyon Smith, Care of Pittsburg Silver Peak Gold Mining Co., Blair, Nev.

HARVARD ENGINEERING SOCIETY OF NEW YORK

The Seventh Annual Dinner of the Harvard Engineering Society of New York was held at the Harvard Club, New York City, on Saturday evening, December 20. There were one hundred and ten members and guests present. J. R. Finlay, '91, President, was toastmaster. The other speakers were Mr. Webb Floyd, President of the Mutual Alliance Trust Co., W. L. Saunders, President of Ingersoll-Rand Co., Professors George C. Whipple, and Hector J. Hughes, of the Graduate School of Applied Science, and John C. Montgomery, Mining Engineer.

In addition to those already mentioned there were present: Professor H. L. Smythe, Professor Wm. H. Burr and Robert Ridgway, honorary members; H. J. Alexander, '00, H. W. Andrews, '05, R. C. Barnard, '02, J. H. Betton, '71, W. E. Belcher,

'04, W. C. Brinton '07, W. L. Bowman, '07, W. F. Booth, '84, E. H. Colpitts, '96, T. Crimmins, '00, F. W. Daggett, '99, T. C. Desmond, '08, R. B. Earle, '00, D. G. Edwards, '03, W. Fairbanks, '95, J. H. Fedeler, '97, E. L. Ford, '08, C. P. Frey, '88, V. M. Frost, '02, C. Gilman, '04, J. F. Gowan, '11, R. W. Greenlaw, '02, G. Hadden, '10, H. M. Hale, '04, J. H. Hawll, '03, W. L. Hanavan, '03, W. Hauck, '96, J. R. Healy, '97, C. Herschel, '60, J. P. Hogan, '03, D. W. Howes, '03, C. M. Holland, '05, S. J. Jennings, '85, A. C. Jackson, '88, A. R. Knowlton, '06, J. M. Levine, '06, F. Mason, '06, J. R. MacArthur, '85, H. E. Mead, '03, W. Meadowcroft, '01, E. Q. Moses, '02, W. H. Page, '83, J. C. R. Palmer, '04, J. P. H. Perry, '03, N. B. Pope, '02, A. S. Proudfoot, '02, F. Remington, '87, G. S. Rice, '70, C. Richardson, '77, R. R. Rumery, '99, M. H. Ryan, '99, J. F. Sanborn, '99, C. Seaver, '02, G. H. Shaw, '04, C. S. Shaughnessy, '01, E. N. Smith, '04, E. Smith, '08, E. L. Sprague, Jr., '03, C. W. Stark, '03, W. F. Stevenson, '97, J. R. Suydam, '09, B. B. Thayer, '85, E. L. Verveer, '98, J. C. Wait, '91, H. Weymouth, '02, J. Weare, '07, E. B. Whittlesey, '05, F. Wilcock, '00, J. E. Woodman, '96.

A smoker was held at the Harvard Club on January 10, forty members attending. An address was given by Professor Henry R. Seager, head of the Economics Department of Columbia University, on the recently enacted "Workmen's Compensation Act of New York State." Informal discussion and refreshments followed.

Inspection was made of the Jacob Ruppert Brewing Plant on the afternoon of February 14, thirty-five members attending. An evening meeting was held at the Harvard Club, at which the Cornell Society of Civil Engineers were guests, eighty men attending. Mr. Henry Bruere, City Chamberlain, gave an address on the New Administration in New York City with particular reference to Efficiency.

The next meeting of the Society was held at the Harvard Club on March 25. The Princeton Engineering Society were guests of the Society. The speakers were Professor Hector J. Hughes, of Harvard University, on the recent Harvard-Technology mer-

ger; Mr. Franklin Remington, on the General Association of Harvard Engineers; and Mr. Ernest A. Reed, on "A Trip from Niagara to the Sea via the St. Lawrence River," with pictures. A large number of men were present.

ROGER C. BARNARD,
Chairman Committee on Meetings.

HARVARD ENGINEERING SOCIETY

On December 17 the Society met with the Boston Society of Civil Engineers in Tremont Temple and listened to speeches by Mr. Rollins of the Holbrook, Cabot, and Rollins Corporation, on "The Fall River Bridge," and Mr. Perkins of the Warren Brothers Company on "Bitulithic Pavement." On January 9 Mr. C. H. Marsh spoke on "Limnology at Squam Lake." On January 23 Mr. J. H. Ripley spoke on "The Seismograph and Earthquake-proof Construction." On February 20 the Society was addressed by Mr. Edmund M. Blake, '99, on "The Improvement of the Neponset River in Massachusetts." On March 6 a committee was appointed, with Mr. T. R. Kendall as chairman, to discuss the advisability of an amendment to Section 3, Article 6 of the Constitution, on Nominations, and to draft the amendment should one be deemed necessary. Mr. Tuttle was appointed a committee of one with whom all members of the society intending to live in Conant Hall next year were advised to consult. Mr. E. G. Sheibley spoke on "Preparation of a Preliminary Report and Application to an Irrigation Project."

Mr. Marsh's paper was reviewed in a preceding issue of the JOURNAL, and a report of Mr. Ripley's speech is printed elsewhere in this number. Articles by Mr. Blake on the Neponset River were printed in November, 1912, and June, 1913.

Mr. Sheibley's speech was condensed from a preliminary report by the Sheibley Engineering Company on an irrigation project in New Mexico some distance above El Paso and near the Rio Grande valley. Seven thousand acres were to be furnished with a supply of water sufficient for the cultivation of alfalfa, and the territory was just beyond the range of country which

might expect to get water from the Elephant Butte dam. A careful study of the geology of the region showed that an adequate ground water supply was available. The report covered the cost of installation of the necessary pumping plant and power station for the distribution of the water, and found that the total yearly charges on the plant would be in the neighborhood of ten dollars an acre, against an income of anything up to seventy dollars or eighty dollars an acre, according to the industry of the tenant.

ERNEST L. ROBINSON, *Secretary.*

GRADUATE NOTES

Calvin M. Woodward, '60, who founded and was a director of the St. Louis Manual Training School, professor emeritus and dean of Washington University, and a Civil War veteran, died at his home in St. Louis on January 12.

Arthur F. Clarke, '76, was one of the Boston delegates to the sixth annual convention of the New England Federation of Harvard Clubs.

Samuel Hill, '79, entertained the Harvard Club of Seattle on the evening of November 8. He provided a "farmer's dinner" which was served in his garage. Informal speeches were the order of the evening.

Howard Elliott, '81, has had two recent addresses printed in pamphlet form: "To the Town Criers of Rhode Island," delivered at Providence on October 29, and "Connecticut and the New Haven Road" delivered before the Chamber of Commerce at New Haven on November 19. On January 30, he made one of the principal addresses at the annual dinner of the New York Harvard Club. Mr. Elliott was also elected an honorary vice-president of the New England Federation of Harvard Clubs at the annual convention on December 20.

Dr. O. W. Huntington, '81, was one of the Rhode Island delegates to the sixth annual convention of the New England Federation of Harvard Clubs.

A. T. Perkins, '87, of St. Louis, southwestern vice-president of the Associated Harvard Clubs, was present at the formation, and of great assistance in the organization, of the Harvard Club of Dallas, Texas, on November 22.

Thomas W. Slocum, '90, was one of the Boston delegates to the sixth annual conventoin of the New England Federation of Harvard Clubs.

W. Cameron Forbes, '92, has been elected a life member of the Corporation of the Massachusetts Institute of Technology.

William F. Baker, '93, is metropolitan manager of the New York Telephone Company, 15 Dey Street, New York City.

Winslow H. Herschel, '96, is assistant physicist in the U. S. Bureau of Standards, Washington, D. C.

Sidney Stevens, '00, is vice-president of the Ludlow Manufacturing Associates, Ludlow, Mass.

Norman R. Willard, '00, is with the Porto Rico Construction Company. His present address is Juana Diaz, Porto Rico, P.O. Box 114.

Athole B. Edwards, '01, is assistant engineer in charge of bridge construction on the southern lines of the Illinois Central Railroad. His address is care of Office of Engineer of Bridges, Illinois Central R.R., Chicago, Ill.

Harry P. Henderson, '01, mining engineer, has moved his office to 66 Broadway, New York City.

Joseph W. Jensen, '01, has recently established residence on his farm near Ogden, Utah, where he is engaged in engineering practice. He has just completed a hydro-electric plant for the purpose of supplying light and power to the State institutions of Utah. His address is R. F. D. No. 4, Ogden, Utah.

Joseph Jenson, '02, is temporarily in charge of construction work at Marysville, Utah. His home address is Springville, Utah, where he is engaged in construction engineering. He had an article on a "Novel Method of Building a Cutoff Cow Trench" in the *Engineering Record* of November 8, 1913.

Herbert A. Jackson, '03, New England sales manager for the Bethlehem Steel Company, was married on November 17 at Fall River, Mass., to Miss Katharine C. Harley. Mr. and Mrs. Jackson will live at 8 Otis Place, Boston.

E. N. Willis, '03, was elected vice-president of the recently-formed Harvard Club of Dallas, Texas.

Jorè P. Katigbak, '04, is in charge of the construction and maintenance of the streets and bridges of the city of Manila. His address is care of the Department of Engineering and Public Works, City Hall, Manila, P. I.

Abbot A. Thayer, '04, after seven years as European representative of the Cincinnati Milling Machine Company, is now in charge of their advertising and publicity department. His address is 9 Linton Street, Cincinnati, Ohio.

Hermann F. Clarke, '05, was a Boston delegate to the sixth annual convention of the New England Federation of Harvard Clubs. He was also a member of the committee which arranged for the meeting.

George L. Huntress, Jr., '05, is in charge of the Boston office, 10 Post Office Square, of the Heine Safety Boiler Company.

L. A. Andrus, '06, was among those present at the annual meeting of the Harvard Club of Portland, Oregon, and later at the joint dinner with the Yale Club of Portland.

William A. Spencer, '06, is Traffic Superintendent of the Michigan State Telephone Company. He is in charge of 3460 telephone girls. His address is 403 Pasadena Apartments, Detroit, Michigan.

S. L. Abraham, '07, is Supervising Engineer for H. Sonneborn & Company. He lives at 2036 Linden Ave., Baltimore, Maryland.

Quincy Adams Brackett, '07, is with the Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa. He is designing engineer in charge of mercury and vibrating recti-

fiers, lightning arresters of all kinds, choke coils, etc. A son, Quincy Adams Brackett, Jr., was born to Mr. and Mrs. Brackett on November 15. His address is 6919 Frankstown Avenue, Pittsburg, Pa.

PERCIVAL W. BROWN, '07, is assistant superintendent of the Crown Hill Cemetery, Indianapolis, Ind. His address is 3847 North Senate Ave., Indianapolis.

C. J. MUNDO, '07, is with the General Electric Company, Pittsburg, Pa.

WALTER M. BIRD, '08, has been acting manager of the Houston (Texas) Electric Company.

CHARLES H. BRACKETT, '08, is an electrical engineer with the Union Carbide Company. His address is 450 12th St., Niagara Falls, New York.

GEORGE A. GEIGER, '08, is with the Bureau of Chemistry, U. S. Department of Agriculture, Washington, D. C.

FREDERIC E. STAEBNER, '08, is teaching mechanical drawing at Hampton Institute, Hampton, Virginia. His home address is Willimantic, Conn.

R. E. BECK, '09, is now living at 35 Conklin Ave., Newark, New Jersey.

FRANK B. DUVENECK, '09, is practicing mechanical engineering. He lives at Waltham, Mass.

WILLARD P. SHEPPARD, '09, was married in Wollaston, Mass., on January 1, to Miss Mollie G. Brown. Mr. and Mrs. Sheppard will be at home after March 1 at 684 Washington St., South Braintree, Mass.

GUY S. DEMING, '10, is assitant engineer with the Watuppa Ponds and Quequechan River Commission. He is also assisting Professor Safford in the Harvard Graduate School of Applied Science. His address is A. J. Borden Building, Fall River, Mass.

PAUL A. MERRIAM, '10, M.M.E. '12, has left the engineering force of the Gricom-Russell Company, New York, to become

assistant to the General Manager of the Smith and Winchester Manufacturing Company, manufacturers of paper mill machinery, of South Windham, Conn.

CHESTER W. RICE, '10, was married on January 14 in Lynn, Mass., to Miss Helen Currier. Mr. and Mrs. Rice will live in Schenectady, N.Y., where he is with the General Electric Company.

GILBERT A. YOUNG, M.M.E. '10, is head of the Department of Mechanical Engineering, Purdue University, LaFayette, Indiana. He made the Germany trip with the A.S.M.E. in the summer of 1913, visiting eight universities and forty-six industrial institutions. He lives at 739 Owen St., LaFayette, Indiana.

AVERY R. SCHILLER, '11, is with Stone and Webster, 147 Milk Street, Boston.

CHESTER S. WENDELL, '11, is district foreman at Fort Lee, N. J., of the Public Service Electric Company. He lives at Palisade, N. J.

RAYMOND G. WILLIAMS, '11, was one of the Rhode Island delegates to the sixth annual convention of the New England Federation of Harvard Clubs.

FREDERICK S. BOYD, '12, has opened an office for the general practice of architecture in the Abbot Building, Harvard Square, Cambridge, Mass.

WALTER S. HOOD, '12, is assistant superintendent for the Purdy-Henderson Construction Company, of New York and Vancouver. He is at present in Saskatchewan at work on the new Royal Bank of Canada. His address is 84 Athabasea St., West, Moose Jaw, Saskatchewan, Canada.

JAMES CAMERON CLARK, '12, is associate professor of electrical engineering at Leland Stanford University. His address is 1010 Emerson Avenue, Palo Alto, Cal.

GEORGE DEFOREST EDWARDS, '12, is with the Western Electric Company, Chicago. His address there is 5902 Midway Park, Austin, Chicago.

Clifton L. Rice, '12, who is with F. A. Barbour, civil and consulting engineer, 73 Tremont Street, Boston, is at present carrying on experiments for the improvement of the water supply of Lowell.

Lincoln C. Torrey, '12, formerly with the Pennsylvania Railroad, Lines West of Pittsburg, is in the engineering department of the American Zinc and Chemical Company, Burgettstown, Pa.

B. Ashburton Tripp, '12, is with William L. Phillips, '08, who is landscape architect to the Isthmian Canal Commission. They are in charge of the designing and building of the new terminal town of Balboa, Panama.

Ernest W. Chapin, '13, is "Vail Librarian" or assistant in charge of the Dering electrical library of the Massachusetts Institute of Technology.

Bruce W. David, '13, is with the Lincoln Electric Company, Cleveland, Ohio.

Edward H. Dignowity, M.M.E. '13, is doing some special work on the water-supply of San Antonio, Texas.

R. R. Martel, Gr. Sc. '13, is instructor in civil engineering at the Rhole Island State College, Kingston, R. I.

Robert C. Weed, Met. E. '13, is with the Anaconda Mining Company, Anaconda, Montana. He lives at 608 Hickory Street.

PERSONAL NOTES

Professor L. S. Marks spoke to the American Society of Refrigerating Engineers at their annual convention in New York on "The Thermo-dynamics of the Compression Process."

Professor Marks is carrying out investigations on the fusing temperature of coal ash with a view to ascertaining the relation between this temperature and the amount of clinker formed in a furnace using the coal. The coals investigated are being burned, both with natural and with forced draft, under one of the boilers at the South Boston plant of the Edison Electric Illuminating Co.

Professor Albert Sauveur delivered an illustrated lecture on "Mild Steel and its Treatment" before the Mechanical Engineering Society of the Worcester Polytechnic Institute on February 6, 1914.

Research in progress under the direction of Professor Sauveur includes: the constitution and properties of high speed steel, heat treatment of manganese steel, crystallography of pure iron.

Professor E. V. Huntington presented a paper at the meeting of the American Mathematical Society in New York on February 28, 1914, entitled: "A Graphical Solution of a Problem in Geology."

Professor H. E. Clifford addressed the Society of Architects and Architectural Engineers of Boston on February 18 on the subject, "Illumination Enginneering and the Architect."

Professor Clifford has been retained by the City of Springfield to advise in regard to a new and improved layout of the system of street lighting in that city and to determine the form for the new contract for such lighting. The problem involves interesting questions in the illumination of a civic centre with its imposing group of municipal buildings. Professor Clifford is at present in conference with the United Electric Light Co. of Springfield on the question of rates for service.

Mr. E. S. Schuman, formerly instructor in Electrical Engineering at Tri-State College, Indiana, is working with Professor Clifford on certain problems connected with dielectric stress, and has designed an apparatus involving a number of new features for the carrying on of experimental work.

Professor Clifford has been retained by the City of Cambridge to determine the selection and installation of a new and improved fire alarm system for the City. The question at issue involves not only a careful study of the detailed parts of such a system but their coöordinated operation in conjunction with certain apparatus already installed.

Professor Clifford has been appointed a member of the National Committee of the National Electric Light Association

to consider the relations of the Association to the educational institutions of the United States. He has also been appointed a member of the National Committee on Education of the Illuminating Engineering Society.

Professor Clifford has recently patented a device to prevent explosions in high power electric switches and has assigned the patent to the General Electric Company.

Mr. Dent Ferrell, a graduate of the University of Illinois in 1913, is carrying on some study of electric power plants adapted for service in cities and towns of moderate size, the work being carried on under Professor Clifford's direction.

Professor Clifford addressed the General Electric Branch of the A.I.E.E. at Lynn on December 17 last, speaking on "Sympathetic Vibrations with some Electrical Applications."

Professor Whipple recently made a visit to several of the Western universities to inspect their laboratories and their methods of teaching Sanitary Engineering. He also delivered lectures on "Relative Values in Sanitation" and "The Sewage Disposal Problem" as follows:

January 19. Northwestern University Medical School at Chicago.
January 20. University of Minnesota at Minneapolis.
January 22. University of Wisconsin at Madison.
January 23. University of Chicago at Chicago.
January 26. University of Illinois at Urbanam.
January 28. Carnegie Technical School at Pittsburgh.
January 29. Baltimore Engineers' Club at Baltimore.

On January 21 the Harvard Club of St. Paul entertained Professor Whipple at lunch at the Minnesota Club. The new agreement between the Harvard University and the Massachusetts Institute of Technology was the subject of an informal talk. The following men were present:

E. P. Davis,	F. B. Tiffany, '87
W. W. Cutler, '94	G. P. Metcalf, '98
M. Barrows, '80	W. G. Graves, '06

E. Hadley, '81
F. J. Otis, '96
A. L. Janes, '05
S. H. E. Freund, '01
R. E. Olds, '97
Dr. B. Crothers, '05
H. B. Wenzell, '75
K. Delaittre, '97

Professor Whipple recently gave a short course of lectures on Water Supply and Sewage Disposal at the Polytechnic Institute of Brooklyn, N. Y.

Mr. C. L. Dawes has been appointed Professor of Electrical Engineering at the United States Naval Academy, Annapolis, to serve during the summer months.

Mr. Dawes and Mr. W. I. Middleton, Engineer of the Simplex Wire and Cable Co., are joint authors of a paper, "Voltage Testing of Cables," which has been accepted by the A.I.E.E. for presentation at the annual convention in June.

Mr. Dawes is carrying on an investigation of the dielectric stresses in cables in connection with his work for the Simplex Wire and Cable Company. He has also recently patented a Separable Transformer.

Mr. F. D. Everett, who received his master's degree in Electrical Engineering at Harvard University in 1913, and who was for a time with Westinghouse, Church, Kerr & Co., is spending the second term as Instructor in Electrical Engineering at Harvard.

Mr. C. D. Hoffman has resigned from the Electrical Engineering Department to accept the position of instructor in Electrical Engineering at the University of Cincinnati.

Mr. F. D. Everett and Mr. A. A. Prior of the Electrical Engineering Department have been assisting Professor Adams in the preparation of the section on "Design" for the new edition of the Standard Handbook. They have also recently standardized certain electric meters to be used by the Boston Elevated Railway Company in its power contract with the Hugh Nawn Construction Company.

Recent Publications by Harvard Men and by the Staff

"Notes on Some Heating and Cooling Curves of Professor Carpenter's Electrolytic Iron." Professor Albert Sauveur. Trans. Am. Inst. Mining Eng., 1914.

"Some Tendencies and Problems of the Present Day and the Relation of the Engineer Thereto," Prof. G. F. Swain, President, Am. Soc. C. E.

Report of the Committee on Water Power, Fifth Conservation Congress held in Washington, November 18-20, 1913. Pamphlet 22 pages.) Prof. G. F. Swain (and others).

NOTES

The students in advanced Electric Railways at the Massachusetts Institute of Technology are taking the regular work in Electric Railways at Harvard this present term in the course under Professor Clifford's direction. This is substituted for their work at Tech., and is one of the first results of the new scheme of coöperation between these two institutions. A number of the instructing staff from Tech. are likewise attending this course.

International Engineering Congress, 1915

Rapid progress is being made in working out the final program of papers for the International Engineering Congress to be held in San Francisco in 1915.

The first volume of the publication of the Congress will consist of a series of articles descriptive of the various technical features of the design and contruction of the Panama canal. The various topics which will be treated are noted in the following list:

(1) Introductory Chapter.

(2) Dry Excavation for the Panama Canal.

(3) Dredging in the Panama Canal.

(4) Terminal Work, Dry Docks, and Wharves of the Panama Canal.

(5) Permanent Shops of the Panama Canal.

(6) Coaling Plants and Floating Cranes of the Panama Canal.

(7) Meteorology and Hydrology of the Panama Canal.

(8) Design of Locks, Dams, and Regulating Works of the Panama Canal.

(9) Method of Construction of the Locks, Dams, and Regulating Works in the Atlantic Division of the Panama Canal.

(10) Method of Construction of the Locks, Dams, and Regulating Works in the Pacific Division of the Panama Canal.

(11) Design of Lock Walls and Valves for the Panama Canal.

(12) Design of the Spillways on the Panama Canal.

(13) Gates of the Panama Canal Locks.

(14) Electrical and Mechanical Institutions of the Panama Canal.

(15) Emergency Dams above Locks of Panama Canal.

(16) Municipal Engineering and Domestic Water Supply in the Canal Zone.

(17) Reconstruction of the Panama Railroads.

(18) Aids to Navigation of the Panama Canal.

(19) Geology of the Panama Canal Zone.

(20) The Working Force of the Panama Canal.

(21) Sanitation in the Panama Canal Zone.

(22) Purchase of Supplies for the Panama Canal.

Each of these topics will be treated by someone on the canal force who has been responsible for the design and construction described. The introductory chapter as well as the topic of Dry Excavation for the Panama Canal will be handled by Colonel Goethals himself.

This volume will constitute practically an official technical record of the gigantic engineering feat which is just nearing completion and will be of interest, not only to engineers but to laymen.

No similar volume has as yet been prepared upon the canal, nor is it probable that any such will be in the future. The advantage is being taken of the Congress to draw together under one cover in this way, the statements of the men who have been responsible for the work.

The program of papers for the various sections of the Congress is practically completed and notices of them will be published in the near future. Subscriptions to the Congress are being received daily, and on March 1 the enrollment was slightly in excess of 1200, of which over 200 are from foreign countries and about 1000 from the United States. Subscription blanks have been mailed through the various National Societies to many thousands of engineers in this country and through the foreign societies to foreign engineers. The response already received is very encouraging, but it is trusted that all engineers interested in the success of the Congress will not fail to send in their subscriptions as early as possible. Delay in so doing renders the task of the Committee of Management more difficult, and makes it impossible to form any just estimate of the receipts which may be expected and the number of copies of the volumes which have to be published.

The following numbers of the

HARVARD ENGINEERING JOURNAL

are

OUT OF PRINT

June	1902 — Vol. I — No. 2
April	1905 — Vol. IV — No. 1
January	1906 — Vol. IV — No. 4

Copies of the above numbers are desired by the editors, and 50 cents each will be paid for copies returned. Or, subscriptions will be extended in proportion of the number of copies returned, if the sender is a subscriber to the Journal and so desires.

Address all communications and return copies to

BUSINESS MANAGER
HARVARD ENGINEERING JOURNAL
218 PIERCE HALL, CAMBRIDGE, MASS.

JUNE, 1913

THE OFFICIAL ORGAN OF THE
ASSOCIATION OF HARVARD ENGINEERS

HARVARD ENGINEERING JOURNAL

A QUARTERLY
DEVOTED TO THE INTERESTS OF
ENGINEERING IN HARVARD UNIVERSITY

VOL. XII. TABLE OF CONTENTS No. 2

Price 35 cents

NOVEMBER, 1913

THE OFFICIAL ORGAN OF THE
ASSOCIATION OF HARVARD ENGINEERS

HARVARD ENGINEERING JOURNAL

A QUARTERLY
DEVOTED TO THE INTERESTS OF
ENGINEERING IN HARVARD UNIVERSITY

VOL. XII. TABLE OF CONTENTS No. 3

Price 35 cents

JANUARY, 1914

THE OFFICIAL ORGAN OF THE
ASSOCIATION OF HARVARD ENGINEERS

HARVARD ENGINEERING JOURNAL

A QUARTERLY
DEVOTED TO THE INTERESTS OF
ENGINEERING IN HARVARD UNIVERSITY

VOL. XII. TABLE OF CONTENTS No. 4

Price 35 cents

INDEX TO ADVERTISERS